This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

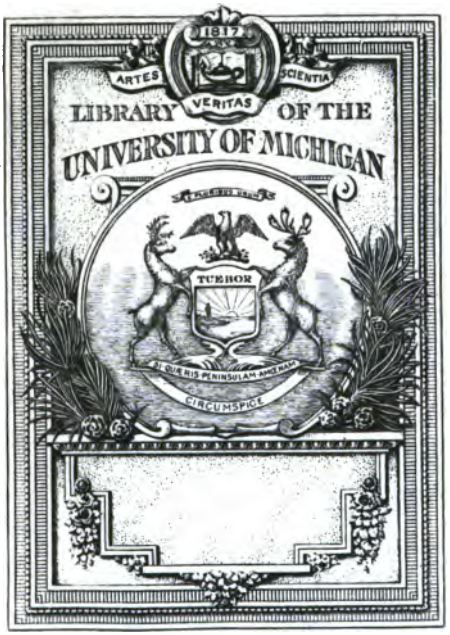
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

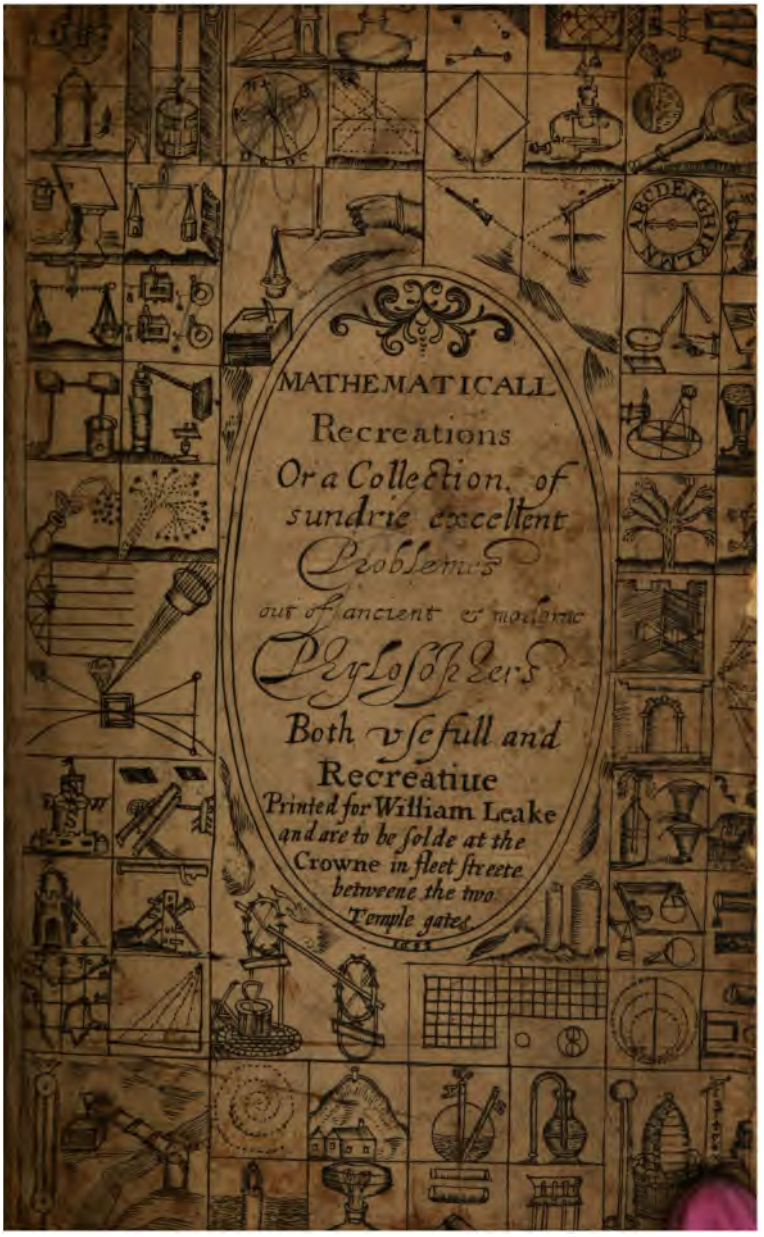
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

R
164
.L65


MATHEMATICALL
Recreations
Or a Collection of
sundrie excellent
Problemes
out of ancient & moderne
Philosophers
Both vsefull and
Recreatiue
Printed for William Leake
and are to be solde at the
Crowne in fleet streete
betweene the two
Temple gates

Q
164
.L653

Mathematicall RECREATIONS.

OR,

A Collection of many *Problemes*,

extracted out of the Ancient and Modern Philosophers, as Secrets and Experiments in *Arithmetick*, *Geometry*, *Cosmographie*, *Horologiographie*, *Astronomie*, *Navigation*, *Musick*, *Opticks*, *Architecture*, *Statick*, *Methanicks*, *Chemistry*, *water-works*, *Fire-works*, &c. Not vulgarly manifest till now.

Written first in *Greeke* and *Latin*, lately compi'ld in *French*, by *Henry Van Etten*, and now in *English*, with the *Examinations* and *Augmentations* of divers *Modern Mathematicians*

Whereunto is added the *Description* and *Use* of the *Generall Horologicall Ring*:

And

The *Double Horizontall Diall*.

Invented and written by

WILLIAM OUGHTRED.

LONDON:

Printed for *William Leake*, at the Signe of the *Crown* in *Fleetstreet*, between the two *Temple* Gates, *MDCLIII*.

Hist. Sciences
9-11-31
2459

TO The thrice Noble and moſt generous Lo. the Lo. *Lambert* Verreyken, Lo. of *Hinden, Wolverthem, &c.*

My honourable Lo.

AMongſt the rare and curious Propoſitions which I have learned out of the ſtudies of the *Mathematicks* in the famous Univerſity of *Pont a Mouſſon*, I have taken ſingular pleaſure in certaine *Problemes* no leſſe ingenious than recreative, which drew me unto the ſearch of demonſtrations more difficult and ſerious; ſome of which I have amaſſed and cauſed to paſſe the *Preſſe*, and here dedicate them now unto your *Honour*; not that I account them worthy of your view, but in part to

testifie my affectionate desires to serve you, and to satisfie the curious, who delight themselves in these pleasant studies, knowing well that the *Nobilitie*, and *Gentrie* rather studie the *Mathematicall Arts*, to content and satisfie their affections, in the speculation of such admirable experiments as are extracted from them, than in hope of gaine to fill their *Purses*. All which studies, and others, with my whole indevours, I shall alwayes dedicate unto your Honour, with an ardent desire to be accounted ever,

Your most humble and obedient Nephew and Servant,

H. VAN ETTEN.

By vvay of advertiſement.

Five or ſix things I have thought worthy to declare before I paſſe further.

First, that I place not the ſpeculative demonſtrations with all theſe *Problems*, but content my ſelf to ſhew them as at the fingers end: which was my plot and intention, becauſe thoſe which underſtand the Mathematicks can conceive them eaſily; others for the moſt part will content themſelves onely with the knowledge of them, without ſeeking the reaſon.

Secondly, to give a greater grace to the practice of theſe things, they ought to be concealed as much as they may, in the ſubtiltie of the way; for that which doth raviſh the ſpirits is, *an admirable effect, whoſe cauſe is unknowne*: which if it were diſcovered, halfe the pleaſure is loſt; therefore all the fineneſſe conſiſts in the dexterity

dexterity of the Act, concealing the meanes, and changing often the ſtreame.

Thirdly, great care ought to be had that one deceive not himſelfe, that would declare by way of Art to deceive another: this will make the matter contemptible to ignorant Perſons, which will rather caſt the fault upon the Science, than upon him that ſhewes it; when the cauſe is not in the Mathematicall principles, but in him that failes in the acting of it.

Fourthly, in certaine Arithmeticall propoſitions they have onely their anſwers as I found them in ſundry Authors, which any one being ſtudious of Mathematicall learning, may finde their originall, and alſo the way of their operation.

Fifthly, becauſe the number of theſe *Problemes*, and their dependances are many, and intermixed, I thought it convenient to gather them into a Table: that ſo each one according to his fancie, might make beſt choiſe of that which might beſt pleaſe his palate, the matter being not of one nature, nor of like ſubtiltie: But whoſoever will have patience to read on, ſhall finde the end better than the beginning.

To

To the Reader.

IT hath been observed by many, that sundry fine wits as well amongst the Ancient as Moderne, have sported and delighted themselves upon several things of small consequence, as upon the foot of a fly, upon a straw, upon a point, nay upon nothing, striving as it were to shew the greatnesse of their glory in the smalnesse of the subject: And have amongst most solid and artificiall conclusions, composed and produced sundry Inventions both Philosophicall and Mathematicall, to solace the minde, and recreate the spirits, which the succeeding ages have imbraced, and from them gleaned and extracted many admirable, and rare conclusions; judging that borrowed matter often-times yeelds praise to the industry of its author. Hence for thy use (Courteous Reader) I have with great

great search and labour collected also, and heaped up together in a body of these pleasant and fine experiments to stirre up and delight the affectionate, (*out of the writings of* Socrates, Plato, Aristotle, Demosthenes, Pythagoras, Democrates, Plinie, Hyparchus, Euclides, Vitruvius, Diaphantus, Pergæus, Archimedes, Papus Alexandrinus, Vitellius, Ptolomæus, Copernicus, Proclus, Mauralicus, Cardanus, Valalpandus, Kepleirus, Gilbertus, Tychonius, Durerus, Josephus Clavius, Galileus Maginus, Euphanus Tybertil, *and others*) *knowing Art imitating Nature that glories always in the variety of things, which she produceth to satisfie the minde of curious inquisitors. And though perhaps these labours to some humourous persons may seeme vaine, and ridiculous, for such it was not undertaken: But for those which intentively have desired and sought after the knowledge of those things, it being an invitation and motive to the search of greater matters, and to imploy the minde in usefull knowledge, rather than to be busied in vaine* Pamphlets, Play-bookes, *fruitlesse* Legends, *and prodigious* Histories *that are invented out of fancie, which abuse many* Noble spirits, *dull their wits, & alien-*

ate

ate their thoughts from laudable and honourable Studies. *In this* Tractate *thou maist therefore make choise of such* Mathematicall Problemes *and Conclusions as may delight thee, which kinde of learning doth excellently adorne a man; seeing the usefulnesse thereof, and the manly accomplishments it doth produce, is profitable and delightfull for all sorts of people, who may furnish and adorne themselves with abundance of matter in that kinde, to help them by way of use, and discourse. And to this we have also added our* Pyrotechnie, *knowing that* Beasts *have for their object only the surface of the* earth; *but hoping that thy spirit which followeth the motion of* fire, *will abandon the lower* Elements, *and cause thee to lift up thine eyes to soare in an higher Contemplation, having so glittering a Canopie to behold, and these pleasant and recreative* fires *ascending may cause thy affections also to ascend. The Whole whereof we send forth to thee, that desirest the serviceability of things; Nature having furnished us with matter, thy spirit may easily digest them, and put them finely in order, though now in disorder.*

A Table of the particular heads of this Book, contracted according to the ſeverall Arts ſpecified in the Title-page.

Experiments of Arithmetick.

Page 1,2,3,16,19,22,28,33,39,40,44,45,51,52,53,59,60,69,71,77,83,85,86,89,90,91,124,134,135,136,137,138,139,140,178,179,181,182,183,184,185,188,208,220,231.

Experiments in Geometrie.

Pag. 12, 15, 24, 26, 27, 30, 35, 37, 41, 42, 47, 48, 49, 62, 65, 72, 79, 82, 103, 117, 118, 119, 214, 215, 217, 218, 234, 235, 236, 239, 240.

Experiments in Coſmographie.

Pag. 14, 43, 75, 106, 107, 219, 220, 225, 227, 228, 229, 230, 232.

Experiments in Horologiographie.

Pag. 137, 166, 167, 168, 169, 171, 214.

Experiments in Aſtronomie.

Pag. 220, 221, 222, 223, 224.

Experiments in Navigation.

Pag. 103, 233, 234, 237, 238.

Experiments in Muſick.

Pag. 86, 87, 226.

&c.

The Table.

Experiments in Opticks.

Pag. 6,66,98,99,100,102,129,131,141,142, 142,144,146,149,151,152,153, 155,156, 157, 158,160,161,162,163,164,165.

Experiments in Architecture.

Pag. 16,242,243.

Experiments in Staticks.

Pag. 27,30,32, 71,199, 200, 201,283,204, 205,207.

Experiments in Machanicks.

Pag. 56, 58, 68,88, 95, 108, 110, 128,173, 174,176,246,248,258,259.

Experiments in Chymistrie.

Pag.198,255,256,257,260, [illegible]63,264.

Experiments in Water-works.

Pag. 190,191 , 192,193, 194,196, 247,249, 250, 252,253.

Experiments in Fireworkes.

From page, 265. to the end.

F I N I S.

A Table of the Contents, and chiefe points conteined in this Book.

PROBLEM. II.

How visible objects that are without, and things that passe by, are most lively represented to those that are within. Page 6.

Prob. 1 *Of finding of numbers conceived in the minde.* 1,2,3

Prob. 5 *Of a Geographicall Garden-plot fit for a Prince or some great personage.* 14.

Prob. 37 *Any liquid substance, as water or wine, placed in a Glasse, may be made to boile by the motion of the finger, and yet not touching it.* 54

Prob. 3 *How to weigh the blow of ones fist, of a Mallet, a Hatchet or such like.* 9.

Prob. 30 *Two severall numbers being taken by two sundry persons, how subtilly to discover which of those numbers each of them took.* 46.

Prob. 4 *That a Glasse may be broken, placed upon two Glasses, without hurting of the Glasses.* 12

Prob. 7 *How to dispose Lots that the 5, 6, 9, &c. of any number of persons may escape.* 16

Prob.

Prob. 13 *How the weight of ſmoke of combuſtible body, which is exhaled, may be weighed.* 27

Prob. 12 *Of three knives which may be ſo diſpoſed to hang in the aire, and move upon the Point of a needle.* 27

Prob. 17 *Of a deceitfull bowle, to bowle withall.* 32

Prob. 16 *A ponderous or heavy body may be ſupported in the aire without any one touching it.* 30

Prob. 18 *How a Peare, or Apple, may be parted into any parts, without breaking the rinde thereof.* 33

Prob. 15 *Of a fine kinde of dore which opens and ſhuts on both ſides.* 30

Prob. 9 *How the halfe of a Veſſell which containes 8 meaſures may be taken, being but onely two other meaſures, the one being 3, and the other 8 meaſures.* 22

Prob. 8 *Three perſons having taken each of them ſeverall things, to finde which each of them hath taken.* 19

Prob. 6 *How to diſpoſe three ſtaves which may ſupport each other in the aire.* 15

Prob. 14 *Many things being diſpoſed Circular (or otherwiſe) to finde which of them any one thinks upon.* 28

Prob. 19 *To finde a number thought upon with-*

without asking quſtions. 33

Prob. 11 *How a Milſtone or other ponderoſity may hang upon the point of a Needle without bowing, or any wiſe breaking of it.* 26

Prob. 20 and 21 *How a body that is uniforme and inflexible may paſſe through a hole which is round, ſquare and Triangular; or round, ſquare and ovall-wiſe, and exactly fill thoſe ſeverall holes.* 35,37

Prob. 10 *How a ſtick may ſtand upon ones finger, or a Pike in the middle of a Court without falling.* 24

Prob. 22 *To finde a number thought upon after another manner than thoſe which are formerly delivered.* 39

Prob. 23 *To finde out many numbers that ſundry perſons or any one hath thought upon.* 40

Prob. 24 *How is it that a man in one & the ſame time may have his head upward, and his feet upward, being in one and the ſame place?* 42

Prob. 25 *Of a Ladder by which two men aſcending at one time, the more they aſcend, the more they ſhal be aſunder, notwithſtanding the one be as high as the other.* 42

Prob. 26 *How is it that a man having but a Rod or Pole of land, doth brag that he*

may in a right line passe from place to place 3000 miles. 42

Prob. 27 *How is it that a man standing upright, and looking which way he will, he looketh true* North *or* South. 43

Prob. 28 *To tell any one what number remaines after certaine operations being ended, without asking any question.* 44

Prob. 29 *Of the play with two severall things.* 45

Prob. 31 *How to describe a* circle *that shall touch 3 points placed howsoever upon a plaine, if they be not in a right line.* 47

Prob. 32 *How to change a circle into a square forme.* 48

Prob. 33 *With one and the same compasses, and at one and the same extent or opening, how to describe many circles concentricall, that is, greater or lesser one than another.* 49

Prob. 34 *Any number under 10. being thought upon, to finde what numbers they were.* 51

Prob. 35 *Of the play with the* Ring. 52

Prob. 36 *The play of 3, 4, or more* Dice. 53

Prob. 38 *Of a fine* Vessell *which holds* Wine *or* Water *being vast into it at a certain height, but being filled higher it will runne all out of its owne accord.* 56

Prob. 39 *Of a* Glaſſe *very pleaſant.* 58

Prob. 40. *If any one ſhould hold in each hand as many pieces of money as in the other, how to finde how much there is.* 59

Prob. 41 *Many* Dice *being caſt, how artificially to diſcover the number of the points that may ariſe.* 60

Prob. 42 *Two* metals *as* Gold *and* Silver *or of other kinde, weighing alike, being privately placed into two like boxes, to finde in which of them the* Gold *or* Silver *is.* 62

Prob. 43 *Two* Globes *of divers metals (as one* Gold *the other* Copper*) yet of equall weight, being put in a* Box *as B. G. to finde in which end the* Gold *or* Copper *is.* 65

Prob. 44 *How to repreſent divers ſorts of* Rainbowes *here below.* 66

Prob. 45 *How that if all the* powder *in the World were incloſed in a bowle of* paper *or* glaſſe, *and being fired on all parts, it could not break that bowle.* 68

Prob. 46 *To finde a number which being divided by 2: there will remaine 1. being divided by 3. there will remaine 1. and ſo likewiſe being divided by 4, 5, or 6. there will ſtill remaine one, but being divided by 7 will remaine nothing.* 69

Prob. 47 *One had a certaine number of* Crownes, *and counting them by 2 and 2, there*

there reſted 1. *counting them by* 3, *and* 3, *there reſted* 2. *counting them by* 4, *and* 4, *there reſted* 3. *counting them by* 5, *and* 5, *there reſted* 4. *counting them by* 6, *and* 6, *there reſted* 5. *but counting them by* 7 *and* 7, *there reſted nothing, how many* Crownes *might he have?* 71

Prob. 48 *How many ſorts of weights in the leaſt manner muſt there be to weigh all ſorts of things betweene one pound and* 121 *pound, and ſo unto* 364 *pound?* 71

Prob. 49 *Of a deceitfull balance which being empty ſeems to be juſt, becauſe it hangs in* Æquilibrio, *notwithſtanding putting* 12 *pound in one ballance, and* 11 *in the other, it will remaine in* Æquilibrio. 72

Prob. 50 *To heave or lift up a bottle with a ſtraw.* 74

Prob. 51 *How in the middle of a wood or deſert, without the ſight of the Sun, ſtarres, ſhadow, or compaſſe, to finde out the* North, *or* South, *or the* 4 Cardinal *points of the World,* Eaſt, Weſt, &c. 75

Prob. 52 *Three perſons having taken* Counters, Cards, *or other things, to finde how much each one hath taken.* 77

Prob. 53 *How to make a conſort of* Muſick *of many parts with one voice or one inſtrument onely.* 78

Prob. 54 *To make or deſcribe an oval form,*

or

or that which is neare reſembled unto it at one turning, with a paire of common Compaſſes. 79

Prob. 55 *Of a* purſe *difficult to be opened.* 80

Prob. 56 *Whether is it more hard and admirable without* Compaſſes *to make a perfect cirtle, or being made to finde out the* Centre *of it?* 82

Prob. 56 *Any one having taken* 3 Cards, *to finde how many* points *they containe.* 83

Prob. 57 *Many* Cards *placed in divers ranks, to finde which of thoſe* Cards *any one hath thought.* 85

Prob. 58 *Many* Cards *being offered to ſundry perſons to finde which of thoſe* Cards *any one thinketh upon.* 86

Prob. 59 *How to make an inſtrument that helps to heare, as* Gallileus *made to help to ſee.* 87

Prob. 60 *Of a fine* Lamp *which goeth not out, though one carries it in ones* pocket, *or being rolled on the ground will ſtill burne.* 88

Prob. 61 *Any one having thought on a* Card *amongſt many* Cards, *how artificially to diſcover it out.* 89

Prob. 62 *Three Women* A, B, C. *carried Apples to a Market to sell: A had* 20. B *had* 30. C 40. *they sold as many for a penny one as the other, and brought home one as much money as another, how could this be?* 90

Prob. 63 *Of the properties of some numbers.* 91

Prob. 64 *Of an excellent* Lamp *which serves or furnisheth it selfe with Oile, and burnes a long time.* 95

Prob. 65 *Of the play at* Keyles *or* Ninepins. 97

Prob. 66 *Of* Spectacles *of pleasure.*

Of Spectacles *which give severall colours to the visage.* 98

Of Spectacles *which make a Towne seeme to be a City, one armed man as a* Company, *and a piece of Gold as many pieces.* 99

How out of a Chamber to see the objects which passe by according to the lively perspective. 100

Of Gallileus *admirable* Optick-Glasse, *which helps one to see the beginning and ending of* Eclipses, *the spots in the Sunne, the Starres which move about the* Planets, *and perspicuously things far remote.*

Of the parts of Gallileus *his* Glasse. 102

Prob. 67 *Of the* Magnes *and* Needles *touched therewith.*

How

How Rings *of* Iron *may hang one by another in the* aire. 103
Of Mahomets *Tombe which hangs in the* aire *by the touch of the* Magnes. 104
How by the Magnes *only to finde out* North *and* South 105
Of a secrecie in the Magnes, *for discovering things farre remote.* 106
Of finding the Poles *by the* Magnes 107
Prob. 68 *Of the properties of* Bolipiles *or* Bowles *to blow the* fire. 108
Prob. 69 *Of the* Thermometer, *or that which measures the degrees of* heat *and* cold *by the* aire. 110
Of the proportion of humane bodies, of statues, of Colosses, or huge Images and monstrous Giants. 113
Of the commensuration of the parts of the bodie the one to the other in particular, by which the Lion was measured by his claw, the Giant *by his thumbe, and* Hercules *by his foot.* 115,116
Of Statues *or* Colosses, *or huge* Images, *that mount* Athos *metamorphosed by* Dynocrates *into a statue, in whose hand was a Towne able to receive ten thousand men.* 117
Of the famous Colossus *at* Rhodes *which had* 70 *cubits in height, and loaded* 900. Camels, *which weighed* 1080000 l. 118

Of

Of Nero *his great* Coloſſus *which had a face of* 12 *foot large.* 119

Of monſtrous Giants

Of the Giant Og *and* Goliah. 119,120

Of the Carkaſſe of a man found which was in length 49 *foot; and of that monſter found in* Creet, *which had* 46. *Cubits of height.* 120

Of Campeſius *his relation of a monſter of* 300 *foot found in* Sicile, *whoſe face according to the former proportion ſhould be* 30 *foot in length.* 121

Prob. 71 *Of the game at the Palme, at Trap, at Bowles, Paile-maile, and others.* 122

Prob. 72 *Of the game of ſquare formes.* 124

Prob. 73 *How to make the ſtring of a Viol ſenſibly ſhake without any one touching it.* 126

Prob. 74 *Of a Veſſell which containes* 3 *ſeverall kindes of liquor, all put in at one bung-hole, and drawne out at one Tap ſeverally without mixture.* 128

Prob. 75 Of burning-Glaſſes.

Archimedes *his way of burning the ſhips of* Syracuſe. 129

Of Proclus *his way, and of concave and ſpherical Glaſſes which burne, the cauſe and demonſtration of burning with Glaſſes.* 131

Of Maginus *his way of ſetting fire to Powder in a Mine by Glaſſes.* 131

Of

Of the examination of burning by Glasses. 133

Prob. 76 Of pleasant questions by way of Arithmetick.

Of the Asse and the Mule. 134

Of the number of Souldiers that fought before old Troy. 135

Of the number of Crownes *that two men had.* 136

About the houre of the day. 137

Of Pythagoras *Schollers.* 137

Of the number of Apples given amongst the Graces and the Muses. 138

Of the testament or last will of a dying Father. 138

Of the cups of Croesus. 139

Of Cupids *Apples.* 139

Of a Mans Age. 140

Of the Lion of Bronze *placed upon a fountaine with his Epigram.* ibid.

Prob. 77 In Opticks, excellent experiments.

Principles touching reflections. 141

Experiments upon flat and plaine Glasses. 142

How the Images seeme to sink into a plaine Glasse, and alwayes are seene perpendicular to the Glasse, ane also inversed. 143

The things which passe by in a ſtreet may by help of a plaine glaſſe be ſeen in a Chamber, and the height of a tower or tree obſerved. 143

How ſeverall Candles from one Candle are repreſented in a plaine Glaſſe, and Glaſſes alternately may be ſeene one within another, as alſo the back-parts of the body as well as the fore-parts are evidently repreſented. 144

How an Image may be ſeene to hang in the aire by help of a Glaſſe: and writing read or eaſily underſtood. 146

Experiments upon *Gibbous*, or convex Spherical Glaſſes.

How lively to repreſent a whole City, fortification, or Army, by a Gibbous *Glaſſe.* 147

How the Images are ſeen in Coneave Glaſſes. 149

How the Images are transformed by approaching to the centre of the Glaſſe, or point of concourſe; and of an exceeding light that a Concave Glaſſe gives by help of a Candle. 151

How the Images, as a man, a ſword, or hand, doth come forth out of the Glaſſe. 152, 153

Of ſtrange apparitions of Images in the aire, by help of ſundry Glaſſes. 152, 154

Of the wonderfull augmentation of the parts of mans body comming neare the point of inflammation, or centre of the Glaſſe. 155

How writing may be reverberated from a Glaſſe upon a Wall, and Read. 156

How by help of a Concave Glaſſe to caſt light into a Campe, or to give a perſpective light to Pyoneers in a Mine, by one Candle only. 156

How excellently by help of a Concave Glaſſe and a Candle

Candle placed in the centre, to give light to read by. 157

Of other Glasses of pleasure. 158

Of strange deformed representations by Glasses; causing a man to have foure eyes, two mouthes, two Noses, two heads.

Of Glasses which give a colour to the visage, and make the face seeme faire and foule. 160

Prob. 78 *How to shew one that is suspicious, what is in another Chamber or Roome, notwithstanding the interposition of that wall.* 160

Corolary 1. *To see the Besiegers of a place, upon the Rampar of a fortification* 161

Corolary 2. *and* 3. *Notwithstanding the interposition of Walls and Chambers, by help of a Glasse things may be seen, which passe by.* 162

Prob. 79 *How with a Musket to strike a marke not looking towards it, as exactly as one aimed at it.* 162

How exactly to shoot out of a Musket to a place which is not seene, being hindred by some obstacle or other interposition. 163

Prob. 80 *How to make an Image to be seen hanging in the aire, having the head downward.* 164

Prob. 81. *How to make a company of representative souldiers seeme to be as a regiment; or how few in number may be multiplyed to seeme to be many in number.* 165

COROLARIE.

Of an excellent delightfull Cabinet made of plaine Glasses. 165

Prob. 82 Of fine and pleasant Dyalls in Horologiographie.

Of a Dyall of herbs for a Garden. 166

Of the Dyall upon the finger and hand, to finde what

of

of the Clock it is. 167

Of a Dyall which was about an Obelisk at Rome. 168

Of Dyals with Glasses. 168

Of a Dyall which hath a Glasse in the place of the stile. 169

Of Dyals with water, which the Ancients usea. 171

Prob. 83 Of shooting out of Cannons or great Artillery.

How to charge a Cannon without powder. 173

To finde how much time the Bullet of a Cannon spends in the Aire before it falls to the ground. 174

How it is that a Cannon shooting upward, the Bullet flies with more violence, than being shot point blanke, or shooting downeward. 174

Whether is the discharge of a Cannon so much the more violent, by how much it hath the more length? 176

Prob. 84 Of prodigious progressions, and multiplications of creatures, plants, fruits, numbers, gold, silver, &c.

Of graines of Mustardseed, and that one graine being sowne, with the increase thereof for 20 yeares will produce a heap greater than all the earth a hundred thousand times. 178

Of Pigges, and that the great Turke *with all his Revenue, is not able to maintaine for one yeare, a Sow with all her increase for 12 yeares.* 179

Of

Of graines of Corne, and that 1 graine with all its increase for 12 yeares, will mount to 24414062500000000000 graines, which exceeds in value all the treasures in the World. 183

Of the wonderfull increase of Sheepe. 182

Of the increase of Cod-fish. 182

Of the Progressive Multiplication of soules; that from one of Noahs *sonnes, from the flood unto* Nimrods *Monarchie, should be produced* 111350 *soules.* 183

Of the increase of Numbers in double proportion, and that a pin being doubled as often as there are weekes in the yeare, the number of pinnes that should arise is able to load 45930 *ships of a thousand Tunne apiece, which are worth more than tenne hundred thousand pounds a day.* 183,184

Of a man that gathered Apples, stones, or such like upon a condition. 185

Of the changes in Bells, in musicall instruments, transmutation of Places, in Numbers, Letters, Men and such like. 185

Of

19 *To ſhew what waters are heavier one than another, and how much.* 206

20 *How to make a pound of water weigh as much as* 10, 20, 30, *or a hundred pound of Lead, nay as much as a thouſand or ten thouſand pound weight.* 207

Prob. 86. Of ſundry queſtions of Arithmetick, and firſt of the number of ſands calculated by *Archimedes* and *Clavius*. 208

2 *Divers metalls being melted together in one body, to finde the mixture of them.* 210

3 *A ſubtile queſtion of three partners about equality of Wine and Veſſels.* 213

4 *Of a Ladder which ſtanding upright againſt a wall of* 10 *foot high, the foot of it is pulled out* 6 *foot from the wall upon the pavement, how much hath the top of the Ladder deſcended.* 214

Prob. 87 *Witty ſuits or debates between* Caius *and* Sempronius, *upon the forme of figures, which* Geometricians *call* Iſoperimeter, *or equall in circuit, or Compaſſe.* 214

1 *Incident: of changing a field of* 6 *meaſures ſquare, for a long rectangled fel of* 9 *meaſures in length and* 3 *in breadth: both equall in circuit but not in quantity.* 215

2 *Incident: about two ſacks each of them holding but a buſhell, and yet were able to hold* 4 *buſhels.* 217

3 *Incident: ſheweth the deceit of pipes which conveygh water, that a pipe of two inches diameter, doth caſt out foure times as much water as a pipe of one ſuch diameter.* 218

7 *Heapes of Corne of* 10 *foot every way, is not as much as one heap of Corne of* 20 *foot every way.* 218

Prob. 88 Of ſundry queſtions in matter of Coſmographie, and Aſtronomy.

In what place the middle of the earth is ſuppoſed to be. 219

Of the depth of the earth, and height of the Heavens, and the compaſſe of the World, how much. 219

How much the ſtarry Firmament, the Sun, and the Moone are diſtant from the centre of the earth. 220

How long a Mill-ſtone would be in falling to the centre of the earth from the ſuperficies, if it might have paſſage thither. 220

How long time a man or a bird may be in compaſſing the whole earth. 220

If a man ſhould aſcend by ſuppoſition 20 *miles every day: how long it would be before he approach to the Moone.* 221

The Sunne moves more in one day than the Moone in 20 *dayes.* 221

If a milſtone from the orbe of the Sun ſhould deſcend a thouſand miles in an houre how long

19 *To ſhew what waters are heavier one than another, and how much.* 206

20 *How to make a pound of water weigh as much as* 10, 20, 30, *or a hundred pound of Lead, nay as much as a thouſand or ten thouſand pound weight.* 207

Prob. 86. Of ſundry queſtions of Arithmetick, and firſt of the number of ſands calculated by *Archimedes* and *Clavius*. 208

2 *Divers metalls being melted together in one body, to finde the mixture of them.* 210

3 *A ſubtile queſtion of three partners about equality of Wine and Veſſels.* 213

4 *Of a Ladder which ſtanding upright againſt a wall of* 10 *foot high, the foot of it is pulled out* 6 *foot from the wall upon the pavement, how much hath the top of the Ladder deſcended.* 214

Prob. 87 *Witty ſuits or debates between* Caius *and* Sempronius, *upon the forme of figures, which* Geometricians *call* Iſoperimeter, *or equall in circuit, or Compaſſe.* 214

1 *Incident: of changing a field of* 6 *meaſures ſquare, for a long rectangled field of* 9 *meaſures in length and* 3 *in breadth: both equall in circuit but not in quantity.* 215

2 *Incident: about two ſacks each of them holding but a buſhell, and yet were able to hold* 4 *buſhels.* 217

3 Incident: ſheweth the deceit of pipes which conveygh water, that a pipe of two inches diameter, doth caſt out foure times as much water as a pipe of one ſuch diameter. 218

7 Heapes of Corne of 10 *foot every way, is not as much as one heap of Corne of* 20 *foot every way.* 218

Prob. 88 Of ſundry queſtions in matter of Coſmographie, and Aſtronomy.

In what place the middle of the earth is ſuppoſed to be. 219

Of the depth of the earth, and height of the Heavens, and the compaſſe of the World, how much. 219

How much the ſtarry Firmament, the Sun, and the Moone are diſtant from the centre of the earth. 220

How long a Mill-ſtone would be in falling to the centre of the earth from the ſuperficies, if it might have paſſage thither. 220

How long time a man or a bird may be in compaſſing the whole earth. 220

If a man ſhould aſcend by ſuppoſition 20 *miles every day: how long it would be before he approach to the Moone.* 221

The Sunne moves more in one day than the Moone in 20 *dayes.* 221

If a milſtone from the orbe of the Sun ſhould deſcend a thouſand miles in an houre how long

it would be before it come to the earth. 221
Of the Sunnes quick motion, of more than 7500 miles in one minute. 221
Of the rapt and violent motion of the ſtarry Firmament, which if a Horſeman ſhould ride every day 40 miles, he could not in a thouſand yeares make ſuch a diſtance as it moves every houre. 221
To finde the Circle of the Sunne by the fingers. 223
Prob. 93 *Of finding the new and full Moone in each moneth.* 224
Prob. 94 *To finde the latitude of Countreys.* 225
Prob. 95 *Of the Climates of Countreys, and how to finde them.* 225
Prob. 96 Of longitude and latitude of the places of the earth, and of the Starres of the Heavens. 227
To finde the Longitude of a Countrey. 228
Of the Latitude of a Countrey. 229
To finde the Latitude of a Countrey. 230
To finde the diſtance of places. 230
Of the Longitude, Latitude, Declination, and diſtance of the ſtarres. 231
How is it that two Horſes or other creatures comming into the World at one time, and dying at one and the ſame inſtant, yet the one of them to be a day older than the other? 232

Certaine

Certaine fine Obſervations.

In what places of the World is it that the needle hangs in Æquilibrio, *and verticall?* 233

In what place of the world is it the ſun is Eaſt or Weſt but twice in the yeare? 233

In what place of the World is it that the Sunnes Longitude from the Equinoctiall points and Altitude, being equall, the Sunne is due Eaſt or Weſt?

That the ſunne comes twice to one point of the Compaſſe in the forenoone or afternoone. 233

That in ſome place of the World there are but two kindes of winde all the yeare. 233

Two ſhips may be two leagues aſunder under the equinoctiall, and ſayling North at a certaine parallell they will be but juſt halfe ſo much. 233

To what inhabitants, and at what time the ſunne will touch the north-part of the Horizon at midnight. 234

How a man may know in his Navigation when he is under the Equinoctiall. 234

At what day in the yeare the extremitie of the ſtyles ſhadow in a Dyall makes a right line. 234

What height the Sunne is of, and how far from the Zenith, or Horizon, when a mans ſhadow

ſhadow is as long as his height. 234
Prob. 97 *To make a Triangle that ſhall have three right Angles.* 234
Prob. 98 *To divide a line in as many parts as one will, without compaſſes or without ſeeing of it.* 235
Prob. 99 *To draw a line which ſhall incline to another line, yet never meet againſt the Axiome of Parallells.* 236
Prob. 100 *To finde the variation of the Compaſſe by the Sunne ſhining.* 237
Prob. 101 *To know which way the winde is in ones Chamber without going abroad.* 238
Prob. 102 *How to draw a parallel ſpherical line with great eaſe.* 239
Prob. 103 *To meaſure an height onely by help of ones Hat.* 240
Prob. 104 *To take an height with two ſtrawes.* 240
In Architecture how ſtatues or other things in high buildings ſhall beare a proportion to the eye below either equall, double, &c. 242
Prob. 106 *Of deformed figures which have no exact proportion, where to place the eye to ſee them direct.* 243
Prob. 107 *How a Cannon that hath ſhot may be covered from the battery of the Enemy.* 244
Prob. 108 *Of a fine Lever, by which one man*

man alone may place a Cannon upon his Carriage. 245
Prob. 109 *How to make a Clock with one wheele* 246

Of Water-workes.

Prob. 110 *How a childe may draw up a Hogshead of water with ease.* 247
Prob. 111 *Of a Ladder of Cords to carry in ones pocket, by which he may mount a wall or Tower alone.* 248
Prob. 112 *Of a marvelous Pump which drawes up great quantity of water.* 249
Prob. 113 *How naturally to cause water to ascend out of a Pit.* 250
Prob. 114 *How to cast water out of a fountaine very high.* 252
Prob. 115 *How to empty the water of a Pit by help of a Cisterne.* 253
Prob. 116 *How to spout out water very high.* 253
Prob. 117 *How to re-animate simples though brought a thousand miles.* 255
Prob. 118 *How to make a perpetuall motion.* 255
Prob. 119 *Of the admirable invention of making the Philosophers Tree, which one may see to grow by little and little.* 256
Prob. 120 *How to make the representation of the great world* 257
Prob. 121 *Of a Cone, or Pyramidall figure that moves upon a Table* 258
Prob. 122 *How an Anvill may be cleaved by the blow of a Pistoll.* 258
Prob. 123 *How a Capon may be roasted in a mans travelling at his saddle-bow.* 259
Prob. 124 *How a Candle may be made to burne three times longer than usually it doth* 259
Prob. 125 *How to draw Wine out of water* 260

Prob.

Prob. 126 *Of two Marmozets, the one of which lights a Candle, and the other blowes it out.* 261
Prob. 127 *How to make Wine fresh without Ice or Snow in the height of Summer.* 262
Prob. 128 *To make a Cement which lastes as marble, resisting aire and water.* 262
Prob. 129 *How to melt metall upon a shell with little fire.* 263
Prob. 130 *Of the hardning of Iron and steele.* 263
Prob. 131 *To preserve fire as long as you will, imitating the inextinguible fire of the Vestales.* 264

FINIS.

Ad Authorem D. D. *Henricum Van Etenium*, Alumnum Academiæ Pontæ Mousson.

ARdua Walkeri fileant secreta profundi,
Definat occultam carpere Porta viam.
Itala Cardani mirata est Lampada docti
Terra, Syracusium Græcia tota senem:
Orbi terrarum, Ptolemæi Clepsydra toti,
Rara dioptra Procli, mira fuêre duo. (num:
Angliate foveat doctus Pont-Mousson alum-
Quidquid naturæ, qui legis, hortus habet.
Docta, coronet opus doctum, te sit tua docto
Digna, Syracusii, arca, corona, viri.
Arca Syracusiis utinam sit plumbea servis,
Aurea sed dominis, aurea tota suis.

MATHEMATICAL RECREATION.

Problem I.

To finde a number thought upon.

Bid him that he Quadruple the Number thought upon, that is, multiply it by 4, and unto it bid him to adde 6, 8, 10, or any Number at pleasure: and let him take the halfe of the sum; then ask how much it coms to, for then if you take away half the number from it which you willed him at first to add to it, there shall remain the double of the number thought upon.

Example

The Number thought upon	5
The Quadruple of it	20
Put 8 unto it, makes	28
The halfe of it is	14

Take away halfe the number added from it, *viz.* 4, the reſt is } 10

The double of the number thought upon, *viz.* 10

Another way to finde what Number was thought upon.

BId him which thinketh double his Number, and unto that double adde 4, and bid him multiply that ſame product by 5, and unto that product bid him adde 12, and multiply that laſt number by 10 (which is done eaſily by ſetting a Cypher at the end of the number) then ask him the laſt number or product, and from it ſecretly ſubtract 320, the remainder in the hundreth place, is the number thought upon.

Example.

The number thought upon	7	For which 700 account onely but the number of the hundreds *viz.* 7. ſo have you the number thought upon.
His double	14	
To it add 4, makes	18	
Which multiplyed by 5 makes	90	
To which add 12 makes	102	
This multiplyed by 10 which is only by adding a Cypher to it, makes	1020	
From this ſubtract	320	
Reſt	700	

To

To finde numbers conceived upon, otherwise than the former.

BId the party which thinks the number, that he triple his thought, and cauſe him to take the half of it: (if it be odde take the leaſt half, and put one unto it:) then will him to triple the half, and take half of it as before: laſtly, aſk him how many nines there is in the laſt half, and for every nine, account four in your memory, for that ſhall ſhew the number thought upon, if both he triples were even: but if it be odde at the firſt triple, and even at the ſecond, for the one added unto the leaſt halfe keep one in memory: if the firſt triple be even, and the ſecond odde, for the one added unto the leaſt halfe keepe two in memory: laſtly, if at both times in tripling, the numbers be odde, for the two added unto the leaſt halfes, keep three in memory, theſe cautions obſerved, and added unto as many fours as the party ſayes there is nines contained in the laſt halfe, ſhall never fail you to declare or diſcern truly what number was thought upon.

Example.

The number thought upon	4 or 7
The triple	12 or 21
The half thereof 6 or 10, one put to it makes	11
The triple of the halfe	18 or 33
The halfe 9 or 16, one put to it makes	17
The number of nines in the laſt halfe	1 or 1

The first 1. representeth the 4. number thought upon, and the last 1. with the caution makes 7. the other number thought upon.

Note.

Order your method so that you be not discovered, which to help, you may with dexterity and industry make *Additions, Substractions, Multiplications, Divisions, &c.* and instead of asking how many nines there is, you may ask how many eights, tens, &c. there is, or substract 8. 10. &c. from the Number which remains, for to finde out the number thought upon.

Now touching the *Demonstrations* of the former directions, and others which follow, they depend upon the 2, 7, 8, and 9, *Book* of the Elements of *Euclide*: upon which 2. *Book* & 4. *proposition* this may bee extracted, for these which are more learned for the finding of any number that any one thinketh on.

Bid the party that thinks, that he break the number thought upon into any two parts, and unto the Squares of the parts, let him adde the double product of the parts, then ask what it amounteth unto, so the *root Quadrat* shall be the number thought upon.

The number thought upon 5, the parts suppose 3 and 2.

The

The ſquare of 3 makes 9
The ſquare of 2 makes 4
The product of the parts. *viz.* 3 by 2 makes 6, which doubled makes 12
} the ſum of theſe three nũbers 25, the *ſquare Root* of which is 5, the *number* thought upon

Or more compendiouſly it may be delivered thus.

Break the number into two parts, and to the product of the parts, adde the ſquare of half the difference of the parts, then the Root Quadrat of the aggregate is halfe the number conceived.

EXAMINATION.

THe Problems *which concern* Arithmetick, *we examine not, for theſe are eaſie to any one which hath read the grounds and principles of* Arithmetick, *but we eſpecially touch upon that, which tends to the ſpeculations of* Phyſick, Geometry, *and* Optickes, *and ſuch others which are of more difficulty, and more principally to be examined and conſidered.*

PROBLEM II.

How to represent to those which are in a Chamber that which is without, or all that which passeth by.

THis is one of the finest experiments in the *Optiques*, and it is done thus, chuse a Chamber or place which is towards the street, frequented with people, or which is against some fair flourishing object, that so it may be more delightfull and pleasant to the beholders, then make the Room dark, by shutting out the light, except a small hole of six pence broad, this done all the *Images* and pecies of the objects which are without, will be seen within, and you shall have pleasure to see it, not only upon the wall, but especially upon a sheet of white paper, or some white cloth hung neer the hole: & if unto the hole you place a round glasse, that is, a glasse which is thicker in the middle than at the edge: such as is the common Burning Glasses, or such which old people use, for then the Images which before did seeme dead, and of a darkish colour, will appear and be seen upon the paper, or white cloth, according

cording to their naturall colours, yea more lively than their naturall, and the appearances will be ſo much the more beautifull and perfect, by how much the hole is leſſer, the day cleere, and the ſun ſhining.

It is pleaſant to ſee the beautifull and goodly repreſentation of the heavens intermixed with clouds in the Horizon, upon a woody ſcituation, the motion of Birds in the Aire, of men and other creatures upon the ground, with the trembling of plants, tops of trees, and ſuch like: for every thing will be ſeen within even to the life, but inverſed; notwithſtanding, this beautifull paint will ſo naturally repreſent it ſelf in ſuch a lively Perſpective, that hardly the moſt accurate Painter can repreſent the like.

Now the reaſon why the Images and objects without are inverſed, is becauſe the ſpecies doe interſect one another in the hole, ſo that the ſpecies of the feet aſcend, and theſe of the head deſcend.

But here note, that they may be repreſented right two manner of wayes; firſt, with a concave glaſſe: ſecondly, by help of another convex glaſſe, diſpoſed or placed between the paper and the other Glaſſe: as may be ſeen here by the figure.

Now

Now I will add here only by passing by, for such which affect Painting and portraicture, that this experiment may excellently help them in the lively painting of things perspectivewise, as *Topographicall cards, &c.* and for Philosophers, it is a fine secret to explain the Organ of the sight, for the hollow of the eye is taken as the close Chamber, the Ball of the Apple of the eye, for the hole of the Chamber, the Crystaline humor at the small of the Glasse, and the bottome of the eye, for the Wall or leafe of paper.

EXAMINATION.

THe species being pressed together or contracted doth not perform it upon a wall, for the species of any thing doth represent it selfe not only in one hole of a window, but in infinite holes, even unto the whole Sphere, *or at least unto a* Hemisphere *(intellectuall in a free medium) if the beams or reflections be not interposed, and by how much the* hole *is made less to give passage to the species, by so much the more lively are the* Images *formed.*

In convexe, or concave Glasses *the* Images *will be disproportionable to the* eye, *by how much they are more concave, or convexe, & by how much the parts of the* image *comes*

neer

neer to the Axis, for those that are neer are better proportioned then those which are farther off.

But to have them more lively and true, according to the imaginary conicall section, let the hole be no greater than a pins head made upon a piece of thin brasse, or such like, which hole represents the top of the Cone, and the Base thereof the term of the species: this practice is best when the sun shines upon the hole, for then the objects which are opposite to that plaine will make two like Cones, and will lively represent the things without in a perfect inversed perspective; which drawn by the Pensill of some artificiall Painter, turn the paper upside down, and it will be direct and to the life.

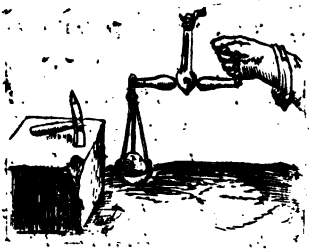
But the apparences may be direct, if you place another hole opposite unto the former, so that the spectater be under it; or let the species reflect upon a concave Glass, and let that glas reflect upon a paper or some white thing.

Problem III.

To tell how much waighs the blow of ones fist, of a Mallet, Hatchet, or such like, or resting without giving the blow

Scaliger in his 331 exercise against Cardan, relates that the Mathematicians of Maximilian the

the Emperour did propose upon a day this *Question*, and promised to give the resolution; notwithstanding *Caliger* delivered it not, and I conceive it to be thus. Take a Balance, and let the Fist, the Mallet, or Hatchet rest upon the scale, or upon the beam of the Balance, and put into the other Scale as much weight as may counterpoyse it; then charging or laying more waight into the Scale, and striking upon the other end, you may see how much one blow is heavier than another, and so consequently how much it may waigh: for as *Aristotle* saith, *The motion that is made in striking adds great waight unto it, and so much the more, by how much it is quicker*: therefore in effect, if there were placed a thousand *mallets*, or a Thousand pounde waight upon a stone, nay, though it were exceedingly pressed down by way of a Vice, by Levers, or other Mechanick Engine, it would be nothing to the rigor and violence of a blow.



Is it not evident that the edge of a knife laid upon butter, and a hatchet upon a leafe of paper, without striking makes no impression, or at least enters not; but striking upon the wood a little, you may presently see what effect it hath, which is from the quickness of the motion, which breaks and enters without resistance, if it be extream quick, as experience shews us in the blows

blows of Arrows, of Cannons, Thunder-boults and ſuch like.

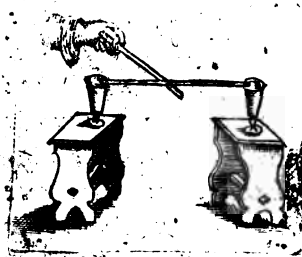
EXAMINATION.

THis Problem *was extracted from* Scaliger, *who had it from* Ariſtotle, *but ſomwhat refractory compiled, & the ſtrength of the effect he ſays depends only in the violence of the motion, then would it follow that a little light* hammer *upon a piece of* wood *being quickly cauſed to ſmite, would give a greater blow, and do more hurt than a great ſledge ſtriking ſoft, this is abſurd, and contrary to experience: therefore it conſiſts not totally in the motion, for if two ſeverall hammers, the one being* 20 *times heavier than the other, ſhould move with like quickneſs, the effect would be much different: there is then ſome thing elſe to be conſidered beſides the Motion which* Scaliger *underſtood not, for if one ſhould have asked him, what is the reaſon that a* ſtone *falling from a* window *to a place neer at hand, is not ſo forceable as if it fell farther down, and when a bullet flying out of a* peece *and ſtriking the mark neer at hand, will not make ſuch an effect as ſtriking the mark further off: but we ſuppoſe that* Scaliger *and* Cardanus *who handles this ſubiect, would not be leſs troubled to reſolve this, than they have been in that.*

Problem IV.

How to break a ſtaffe which is laid upon two Glaſſes full of water, without breaking the Glaſſes, ſpilling the water, or upon two reeds or ſtraws without breaking of them.

FIrſt, place the Glaſſes which are full of water upon two joynt ſtooles, or ſuch like, the one as high as the other from the ground, and diſtant one from another by 2 or 3 foot, then place the ends of the ſtaffe upon the edges of the two Glaſſes ſo that they be ſharp, this done, with all the force you can, with another ſtaffe ſtrike the ſtaffe which is upon the two Glaſſes in the middle, and it will breake without breaking the Glaſſes or ſpilling the water.



In like manner may you doe upon two Reeds, held with your hands in the ayre without breaking them: thence Kitchin boyes often break bones of mutton upon their hand, or with a napkin without any hurt, in only ſtriking upon the middle of the bone with a knife.

Now

Now in this act, the two ends of the ſtaffe in breaking ſlides away from the Glaſſes, upon which they were placed; hence it commeth that the Glaſſes are no wiſe indangered, no more than the knee upon which a ſtaffe is broken, foraſmuch as in breaking it preſſeth not; as *Ariſtotle* in his *Mechanick Queſtions* obſerveth.

EXAMINATION.

IT were neceſſary here to note, that this thing may be experimented, firſt, without Glaſſes, *in placing a ſmall ſlender ſtaffe upon two props, and then making tryall upon it, by which you may ſee how the* Staffe *will either break, bow, or depart from his props, and that either directly or obliquely: But why by this violence, that one* Staffe *ſtriking another, (which is ſupported by two* Glaſſes) *will be broken without offending the* Glaſſes, *is as great a difficulty to be reſolved as the former.*

PROBLEM V.

How to make a faire Geographicall Card in a Garden Plot, fit for a Prince, or great personage.

IT is usuall amongst great men to have faire *Geographicall Maps*, large *Cards*, and great *Globes*, that by them they may as at once have a view of any place of the World, and so furnish themselves with a generall knowledge, not only of their own Kingdoms form, scituation, longitude, latitude, &c. but of all other places in the whole Universe, with their magnitudes, positions, Climats, and distances.

Now I esteem that it is not unworthy for the meditations of a Prince, seeing it carries with it many profitable and pleasant contentments: if such a Card or Map by the advice and direction of an able Mathematician were Geographically described in a Garden plot form, or in some other convenient place, and instead of which generall description might particularly and artificially be prefigured his whole Kingdoms and Dominions, the Mountains and hils being raised like small hillocks with turfs of earth, the valleys somwhat concave, which will be more agreeable and pleasing to the eye, than the description in plain Maps and Cards, within which may be presented the Towns, Villages, Castles, or other remarkable edifices in small green mossie banks, or spring-work proportionall to the plat-

form,

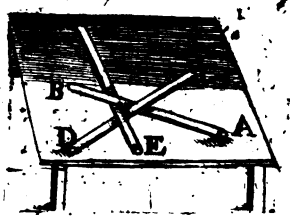
form, the Forrests and Woods represented according to their form and capacity, with herbs and stoubs, the great Rivers, Lakes, and Ponds to dilate themselves according to their course from some artificiall Fountain made in the Garden to passe through chanels; then may there be composed walks of pleasure, ascents, places of repose, adorned with all variety of delightfull herbs and flowers, both to please the eye or other senses. A Garden thus accommodated shall farre exceed that of my Lord of *Verulams* specified in his Essayes; that being only for delight and pleasure, this may have all the properties of that, and also for singular use, by which a Prince may in little time personally visit his whole Kingdom, and in short time know them distinctly: and so in like manner may any particular man Geographically prefigure his own possession or heritage.

PROBLEM VI.

How three staves, knives, or like bodies, may be conceived to hang in the aire, without being supported by any thing but by themselves.

TAke the first staffe A B, raise up in the aire the end B, and upon him crosse-wise place the staffe C B, then lastly, in Triangle wise place the third staffe E F in such manner that it may be under A B, and yet upon C D. I say that these staves so disposed cannot fall, and the

the ſpace C B E is made the ſtronger, by how much the more it is preſſed downe, if the *ſtaves* break not, or ſever themſelves from the *triangular* forme: ſo that alwayes the Center of gravitie be in the Center of the *Triangle*: for A B is ſupported by E F, and E F is held up by C D, and C D is kept up from falling by A B, therefore one of theſe *ſtaves* cannot fall, and ſo by conſequence none.



PROBLEM VII.

How to diſpoſe as many men, or other things in ſuch ſort, that rejecting, or caſting away the 6, 9, 10 part, unto a certain number, there ſhall remaine theſe which you would have.

ORdinarily the propoſition is delivered in this wiſe: 15 *Chriſtians* and 15 *Turkes* being at Sea in one *Shippe*, an extreame tempeſt being riſen, the Pilot of the *Shippe* ſaith, it is neceſſary to caſt over board halfe of the number of *Perſons* to disburthen the *Shippe*, and ſo

to ſave the reſt: now it was agreed to be done by lot, and therefore they conſent to put themſelves in rank, counting by nine and nine, the ninth Perſon ſhould alwayes be caſt into the Sea, untill there were halfe throwne over board; Now the Pilote being a Chriſtian indeavoured to ſave the Chriſtians, how ought he therefore to diſpoſe the Chriſtians, that the lot might fall alwayes upon the Turkes, and that none of the Chriſtians be in the ninth place?

The reſolution is ordinarily comprehended in this verſe.

Populeam virgam mater regina ferebat.

For having reſpect unto the vowels, making *a* one, *e* two, *i* three, *o* foure, and *u* five: *o* the firſt vowell in the firſt word ſheweth that there muſt be placed 4. Chriſtians; the next vowel *u*, ſignifieth that next unto the 4. Chriſtians muſt be placed 5 Turkes, and ſo to place both Chriſtians and Turkes according to the quantity and value of the vowels in the words of the verſe, untill they be all placed: for then counting from the firſt Chriſtian that was placed, unto the ninth, the lot will fall upon a Turk, and ſo proceed. And here may be further noted that this Probleme is not to be limited, ſeeing it extends to any number and order whatſoever, and may many wayes be uſefull for Captaines, Magiſtrates, or others which have divers perſons to puniſh, and would chaſtiſe chiefely the unrulieſt of them, in taking the 10, 20, or 100. perſon, &c. as we reade was

commonly practiſed amongſt the ancient Romans: herefore to apply a generall rule in counting the third, 4, 9, 10, &c. amongſt 30, 40, 50, perſons, and more or leſſe, this is to be obſerved, take as many units as there are perſons, and diſpoſe them in order privately: as for example, let 24 men be propoſed to have committed ſome outrage, 6 of them eſpecially are found acceſſary: and let it be agreed that counting by 8 and 8 the eight man ſhould be alwayes puniſhed. Take therefore firſt 24 units, or upon a piece of paper write down 24 cyphers, and account from the beginning to the eighth, which eighth mark, and ſo continue counting alwayes marking the eighth, untill you have mark't 6, by which you may eaſily perceive how to place thoſe 6 men that are to be puniſhed, and ſo of others.

It is ſuppoſed that *Joſephus* the Author of the *Jewiſh Hiſtory* eſcaped the danger of death by help of this Problem; for a worthy Author of beliefe reports in his eighth chapter of the third Book of the deſtruction of *Jeruſalem*, that the Town of *Jotapata* being taken by main force by *Veſpatian*, *Joſephus* being Governour of that Town, accompanyed with a Troop of forty Souldiers, hid themſelves in a Cave, in which they reſolved rather to famiſh than to fall into the hands of *Veſpatian*: and with a bloudy reſolution in that great diſtreſſe would have butchered one another for ſuſtenance, had not *Joſephus* perſwaded them to die by lot and order, upon which it ſhould fall: Now

seeing that *Iosephus* did save himselfe by this Art, it is thought that his industry was exercised by the helpe of this Problem, so that of the 40 persons which he had, the third was alwayes killed. Now by putting himselfe in the 16 or 31 place he was saved, and one with him which he might kill, or easily perswade to yeild unto the Romans.

PROBLEM. VIII.

Three things, and three persons proposed, to finde which of them hath either of these three things.

LEt the three things be a *Ring*, a piece of *Gold*, and a piece of *Silver*, or any other such like, and let them be known privately to your self by these three Vowels *a, e, i*, or let there be three persons that have different names, as *Ambrose*, *Edmond*, and *John*, which privately you may note or account to your selfe once known by the aforesaid Vowels, which signifie for the first vowel 1, for the second vowell 2, for the third vowell 3.

Now if the said three persons should by the mutuall consent of each other privately change their names, it is most facill by the course and excellencie of numbers, distinctly to declare each ones name so interchanged, or if three persons in private, the one should take a *Ring*, the

other a piece of Gold, and the third ſhould take a piece of Silver; it is eaſie to finde which hath the Gold, the Silver, or the Ring, and it is thus done.

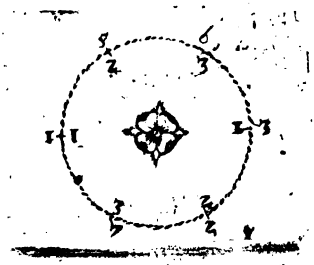
Take 30 or 40 Counters (of which there is but 24 neceſſary) that ſo you may conceale the way the better, and lay them down before the parties, and as they ſit or ſtand, give to the firſt 1. Counter, which ſignifieth *a*, the firſt vowell; to the ſecond 2. Counters, which repreſent *e*, the ſecond vowel; and to the third 3. Counters, which ſtand for *i*, the third vowell: then leaving the other Counters upon the Table, retire apart, and bid him which hath the Ring, take as many Counters as you gave him, and he that hath the Gold, for every one that you gave him, let him take 2, and he that hath the Silver for every one that you gave him, let him take 4. this being done, conſider to whom you gave one Counter, to whom two, and to whom three; and mark what number of Counters you had at the firſt, for there are neceſſarily but 24. as was ſaid before, the ſurpluſe you may privately reject. And then there will be left either 1.2.3.5.6 or 7. and no other number can remaine, which if there be, then they have failed in taking according to the directions delivered: but if either of theſe numbers do remaine, the reſolution will be diſcovered by one of theſe 6 words following, which ought to be had in memory, *viz.*

Salve, certa, anima, femina, vina, quias.
1. 2. 3. 5. 6. 7.

As

As ſuppoſe 5. did remaine, the word belonging unto it is *ſemita*, the vowels in the firſt two ſyllables are *e* and *i*, vvhich ſhevveth according to the former directions, that to vvhom you gave 2 Counters, he hath the Ring (ſeeing it is the ſecond vovvell repreſented by tvvo as before) and to vvhom you gave the 3. Counters, he hath the Gold, for that *i* repreſents the third vovvel, or 3. in the former direction, and to vvhom you gave one Counter, he hath the Silver, and ſo of the reſt: the variety of changes, in vvhich exerciſe, is laid open in the Table followving.

reſt	men	hid	reſt	men	hid
	1	*a*		1	
1	2	*e*	5.	2	
	3	*i*		3	
	1	*e*		1	
2	2	*a*	6	2	
	3	*i*		3	
	1	*a*		1	
3	2	*i*	7	2	
	3	*e*		3	



This feat may be done alſo without the former words by help of the Circle *A*. for having divided the Circle into 6 parts, write 1. within and 1. vvithout, 2. vvithin and 5. vvithout, &c. the firſt 1. 2. 3. vvhich are vvithin vvith the numbers over them, belongs to the upper ſemicircle; the other numbers both vvithin and vvithout, to the under ſemicircle;

now if in the action there remaineth ſuch a number which may be found in the upper ſemicircle without, then that which is oppoſite within ſhews the firſt, the next is the ſecond, &c. as if 5 remains, it ſhews to whom he gave 2, he hath the *Ring*; to whom you gave 2, he hath the *Gold*, &c. But if the remainder be in the under ſemicircle, that which is oppoſite to it is the firſt; the next backwards towards the right hand is the ſecond; as if 3 remains, to whom you gave 1 he hath the *Ring*, he that had 3 he had the *Gold*, &c.

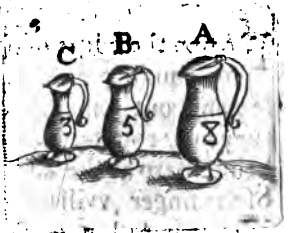
Problem IX.

How to part a Veſſel which is full of wine conteining eight pints into two equall parts, by two other veſſels which conteine as much as the greater veſſell; as the one being 5 pints, and the other 3 pints.

LEt the three veſſels be repreſented by A B C, A being full, the other two being empty; firſt, poure out A into B until it be full, ſo there will be in B 5 pints, and in A but 3 pints: then poure out of B into C untill it be full: ſo in C ſhall be 3 pints, in B 2 pints, and in A 3 pints, then poure the wine which is in C into A, ſo in A will be 6 pints, in B 2 pints, and in C nothing: then poure out the wine which is in B into the

pot

pot C, ſo in C there is now 2 pints, in B nothing, and in A 6 pints,. Laſtly, poure out of A into B untill it be full, ſo there will be now in A only 1 pint, in B 5 pints, and in C 2 pints. But it is now evident, that if from B you poure into the pot C untill it be full, there wil remain in B 4 pints, and if that which is in C, *viz.* 3 pints be poured into the veſſell A, which before had 1 pint, there

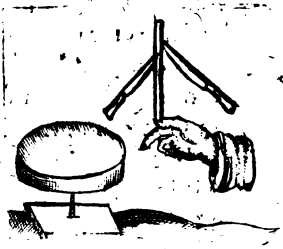


ſhall be in the veſſel A, but halfe of its liquor that was in it at the firſt, *viz.* 4 pints as was required. Otherwiſe poure out of A into C untill it be full, which pour into B, then poure out of A into C again untill it be full, ſo there is now in A onely 2 pints, in B 3, and in C 3, then pour from C into B untill it be full, ſo in C there is now but 1 pint, 5 in B, and 2 in A: poure all that is in B into A, then poure the wine which is in C into B, ſo there is in C nothing, in B onely 1 pint, and in 7 A 7 pints: Laſtly, out of A fill the pot C, ſo there will remain in A 4 pints, or be but halfe full: then if the liquor in C be poured into B, it will be the other half. In like manner might be taken the half of a veſſell which conteins 12 pints, by having but the meaſures 5 and 7, or 5 and 8. Now ſuch others might be propoſed, but we omit many, in one and the ſame nature.

PROBLEM. X.

To make a ſtick ſtand upon the tip of ones finger, without falling.

FAſten the edges of two knives or ſuch like of equall poiſe, at the end of the ſtick, leaning out ſomewhat from the ſtick, ſo that they may counterpoiſe one another; the ſtick being ſharp at the end, and held upon the top of the finger, will there reſt without ſupporting: if it fall, it muſt fall together, and that perpendicular or plumb-wiſe, or it muſt fall ſide-wiſe or before one another; in the firſt manner it cannot: for the Centre of gravitie is ſupported by the top of the finger: and ſeeing that each part by the knives is counterpoiſed, it cannot fall ſidewiſe, therefore it can fall no wiſe.



In like manner may great pieces of Timber, as Joiſts, &c be ſupported, if unto one of the ends be applied convenient proportionall counterpoiſes, yea a Lance or Pike, may ſtand perpendicular in the Aire upon the top of ones finger: or placed in the midſt of a Court by help of his Centre of gravitie.

EXAMI-

EXAMINATION.

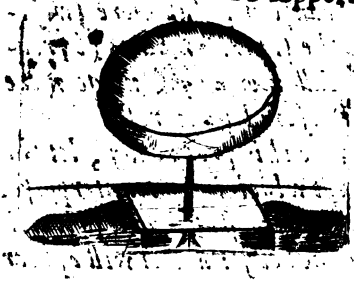
This Propoſition ſeems doubtfull; for to imagine abſolutely, that a Pike, or ſuch like, armed with two Knives, or other things, ſhall ſtand upright in the Aire, and ſo remain without any other ſupport, ſeeing that all the parts have an infinite difference of propenſity to fall; and it is without queſtion that a ſtaff ſo accommodated upon his Centre of gravity, but that it may incline to ſome one part without ſome remedy be applied, and ſuch as is here ſpecified in the Probleme will not warrant the thing, nor keep it from falling; and if more Knives ſhould be placed about it, it ſhould cauſe it to fall more ſwiftly, for aſmuch as the ſuperiour parts (by reaſon of the Centricall motion) is made more ponderous, and therefore leſſe in reſt.

To place therefore this propreally, let the two Knives, or that which is for counterpoiſe, be longer always then the ſtaffe, and ſo it will hang together as one body: and it will appear admirable if you place the Centre of gravity, neer the ſide of the top of the finger or point; for it will then hang Horizontall, and ſeem to hang onely by a touch, yet more ſtrange, if you turn the point or top of the finger upſide down.

PROBLEM XI.

How a milſtone or other Ponderoſity, may be ſupported by a ſmall needle, without breaking, or any wiſe bowing the ſame.

LEt a needle be ſet perpendicular to the *Horizon*, and the center of gravitie of the ſtone be placed on the top of the needle: it is evident that the ſtone cannot fall, forasmuch as it hangs in *equilibrio*, or is counterpoyſed in all parts alike; and moreover it cannot bow the needle more on the one ſide then on the other, the needle will not therefore be either broken or bowed; if otherwiſe then the parts of the needle muſt penetrate and ſinke one with another: that which is abſurd and impoſſible to nature; therefore it ſhall be ſupported. The experiments which are made upon trencher plates, or ſuch like leſſer thing doth make it moſt credible in greater bodies.



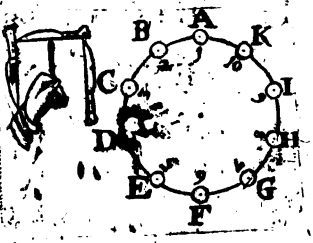
But here eſpecially is to be noted, that the needle ought to be uniforme in matter and figure, and that it be erected perpendicular to the *Horizon*, and laſtly, that the *Center of gravitie* be exactly found.

PROB.

Problem XII.

To make three Knives hang and move upon the point of a Needle.

FIt the three *Knives* in form of a *Ballance*, and holding a *Needle* in your hand, and place the back of that Knife which lyes croſſ-wiſe to the other two, upon the point of the Needle: as the figure here ſheweth you; for then in blowing ſoftly upon them, they will eaſily turne and move upon the point of the Needle without falling.



Problem XIII.

To finde the weight of Smoak, which is exhaled of any combuſtible body whatſoever.

LEt it be ſuppoſed that a great heape of Fagots, or a load of ſtraw weighing 500 pound ſhould be fired, it is evident that this groſſe ſubſtance will be all inverted into ſmoak and aſhes: now it ſeems that the *ſmoak* weighs nothing; ſeeing it is of a thin ſubſtance now dilated in the Aire, notwithſtanding if it were gathered and reduced into the thickeſt that it was at firſt, it would be ſenſibly weighty: weigh therefore the aſhes which admit 50 pound, now ſeeing that the

the reſt of the matter is not loſt, but is exhaled into *ſmoake*, it muſt neceſſarily be, that the reſt of the weight (to wit) 450 pound, muſt be the weight of the *ſmoak* required.

EXAMINATION.

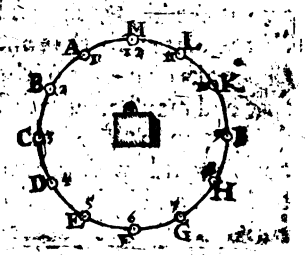
NOw although it be thus delivered, yet here may be noted, that a ponderoſity in his own medium is not weighty: for things are ſaid to be weighty, when they are out of their place, or medium, and the difference of ſuch gravity, is according to the motion: the ſmoak therefore certainly is light being in its true medium (the aire,) if it ſhould change his medium, then would we change our diſcourſe.

PROBLEM XVI.

Many things being diſpoſed circular, (or otherwiſe) to finde which of them, any one thinks upon.

SUppoſe that having ranked 10 things, as A B C D E F G H I K, Circular (as the figure ſheweth) and that one had touched or thought upon G, which is the 7: ask the party at what letter

letter he would begin to account (for account he muſt, otherwiſe it cannot be done) which ſuppoſe, at E which is the 5 place, then add ſecretly to this 5, 10 (which is the number of the Cirtle) and it makes 15, bid him account 15 backward from E, beginning his account with that number hee thought upon, ſo at E he ſhal account to himſelf 7, at D account 8, at C account 9, &c. So the account of 15 wil exactly fall upon G, the thing or number thought upon: and ſo of others: but to conceal it the more, you may will the party from E to account 25, 35, &c. and it will be the ſame.



There are ſome that uſe this play at Cards, turned upſide downe, as the ten ſimple Cards, with the King and Queen, the King ſtanding for 12, and the Queene for 11, and ſo knowing the ſituation of the Cards: and thinking a certain houre of the day: cauſe the party to account from what Card he pleaſeth: with this Proviſo, that when you ſee where he intends to account, ſet 12 to that number, ſo in counting as before, the end of the account ſhall fall upon the Card: which ſhall denote or ſhew the houre thought upon, which being turned up will give grace to the action, and wonder to thoſe that are ignorant in the cauſe.

PROP.

Problem XV.

How to make a Dore or Gate, which ſhall open on both ſides.

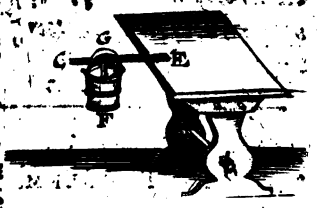
ALL the skill and ſubtilty of this, reſts in the artificiall diſpoſer of foure plates of Iron, two at the higher end, and two at the lower end of the Gate: ſo that one ſide may move upon the hooks or hinges of the Poſts, and by the other end may be made faſt to the Gate, and ſo moving upon theſe hinges, the Gate will open upon one ſide with the aforeſaid plates, or hooks of Iron: and by help of the other two plates, will open upon the other ſide.

Problem XVI.

To ſhew how a Ponderoſity, or heavy thing, may be ſupported upon the end of a ſtaffe (or ſuch like) upon a Table, and nothing holding or touching it.

TAke a pale which hath a handle, and fill it full of water (or at pleaſure:) then take a ſtaffe or ſtick which may not rowle upon the Table as E C, and place the handle of the Pale upon the ſtaffe; then place another ſtaffe, or ſtick, under the ſtaffe C B, which may reach from the bottom of the Pale unto the former ſtaffe C E, perpendicular wiſe: which ſuppoſe F G, then ſhall the Pale of water hang without fal-

falling, for if it fall it must fall perpendicularly, or plumbe wiſe: and that cannot be ſeeing the ſtaffe C E ſupports it, it being parallel to the Horizon and ſuſteined by the Table, and it is a thing admirable that if the ſtaffe C E were alone from the table, and that end of the ſtaffe which is upon the Table were greater and heavier than the other: it would be conſtrained to hang in that manner.



EXAMINATION.

NOt without ſome experience of this Problème, a man would acknowledge either a poſsibility or impoſsibity: therefore it is that very touchſtone of knowledge in anything, to diſcourſe firſt if a thing be poſſible in nature, and then if it can be brought to experience and under ſence without ſeeing it done. At the firſt, this propoſition ſeems to be abſurd, and impoſſible. Notwithſtanding, being ſupported with

with two ſticks, as the figure declareth, it is made facile: for the Horizontall line to the edge of the Table, is the Centre of motion; and paſſeth by the Centre of gravity, which neceſſarily ſupporteth it.

Problem XVII.

Of a deceitfull Bowle to play withall.

MAke a hole in one ſide of the Bowle, and caſt molten Lead therein, and then make up the hole cloſe, that the knavery or deceit be not perceived: you will have pleaſure to ſee, that notwithſtanding the Bowle is caſt directly to the play, how it wil turn away ſide-wiſe: for that on that part of the Bowle which is heavier upon the one ſide then on the other, it never will go truly right, if artificially it be not corrected; which will hazard the game to thoſe which know it not: but if it be known that the leady ſide in rolling be always under or above, it may go indifferently right; if otherwiſe, the weight will carry it always ſide-wiſe.

Prob.

PROBLEM. XVIII.

To part an Apple into 2.4.or 8.like parts, without breaking the Rinde.

PAsse a needle and threed under the kinde of the Apple, and then round it with divers turnings, untill you come to the place where you began: then draw out the threed gently, and part the Apple into as many parts as you think convenient: and so the parts may be taken out between the parting of the Rind, and the rind remaining alwayes whole.

PROBLEM XIX.

To finde a number thought upon without asking of any question, certaine operations being done.

BId him adde to the number thought (as admit 15) halfe of it, if it may be, if not the greateſt halfe that exceeds the other but by an unite, which is 8; and it makes 23. Secondly, unto this 23. adde the halfe of it if it may be, if not, the greateſt halfe, *viz.* 12. makes 35. in the meane time, note that if the number thought upon cannot be halfed at the firſt time, as here it cannot, then for it keep 3 in the memory, if at the ſecond time it will not be

equally halfed, reſerve 2 in memory, but if at both times it could not be equally halved, then may you together reſerve five in memory: this done, cauſe him from the laſt ſumme, *viz.* 35. to ſubtract the double of the number thought, *viz.* 30. reſt 5. will him to take the halfe of that if he can, if not, reject 1. and then take the halfe of the reſt, which keep in your memory: then will him to take the halfe againe if he can, if not, take one from it, which reſerve in your memory, and ſo perpetually halveing untill 1. remaine: for then mark how many halfes there were taken, for the firſt halfe account 2, for the ſecond 4, for the third 8, &c. and adde unto thoſe numbers the ones which you reſerved in memory, ſo there being 5 remaining in this propoſition, there were 2 halfings: for which laſt 1 account 4, but becauſe it could not exactly be halved without rejecting of 1. I adde the 1 therefore to this 4, makes 5, which halfe or ſumme alwayes multiplied by 4, makes 20. from which ſubtract the firſt 3 and 2, becauſe the halfe could not be formerly added, leaves 15, the number thought upon.

Other

Other Examples.

The number thought	12
The halfe of it	6
The ſumme	18
The halfe of it	9
The ſumme of it	27
The double of the number,	24
Which taken away, reſts	3
The halfe of it	1
For which account	2
and 1 put to it becauſe the could not be halfed, makes	3
this multiplied by 4 makes	12

The number thought upon.

The number thought	79
The greateſt halfe	40 3
The ſumme	119
The greateſt halfe of which is	60 2
The ſumme of it is	179
The double of 79 is	158
Which taken from it, reſts	21
The leſſer half 10. wch halves:	
The halfe of this is 5 which makes	
The half of this is 2 wch is 10	
The half of this is 1, with 10 and 11 is 21.	

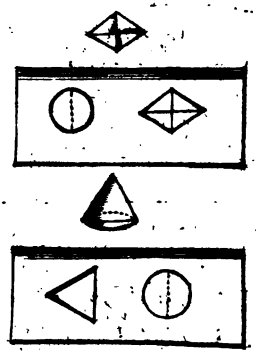
this 21 which is the double of the laſt halfe with the remainder being multiplied by 4. makes 84, from which take the aforeſaid 3 and 2, reſt 79, the number thought upon.

PROBLEME XX.

How to make an uniforme; & an inflexible body, to paſſe through two ſmall holes of divers formes. as one being circular, and the other ſquare, Quadrangular, and Triangular-wiſe, yet ſo that the holes ſhall be exactly filled.

THis Probleme is extracted from Geometricall obſervations, and ſeemes at the firſt

ſomewhat obſcure, yet that which may be extracted in this nature, will appeare more difficult and admirable. Now in all Geometricall practiſes, the leſſer or eaſier Problemes do alwayes make way to facilitate the greater: and the aforeſaid Probleme is thus reſolved. Take a Cone or round Pyramide, and make a Circular hole in ſome board, or other hard material, which may be equall to the baſes of the Cone, and alſo a Triangular hole, one of whoſe ſides may be equall to the Diameter of the circle, and the other two ſides equall to the length of the Cone: Now it is moſt evident, that this Conicall or Pyramidall body, will fill up the Circular hole, and being placed ſide-wiſe will fill up the Triangular hole. Moreover, if you cauſe a body to be turned, which may be like to two Pyramides conjoyned, then if a Circular hole be made, whoſe Diameter is equal to the Diameter of the Cones conjoyned, and a Quadrangular hole, whoſe ſloping ſides be equall to the length of each ſide of the Pyramide, and the breadth of the hol equal to the Diameter of the Circle, this conjoyned Pyramide ſhall exactly fill both the Circular hole, and alſo the Quadrangle hole.

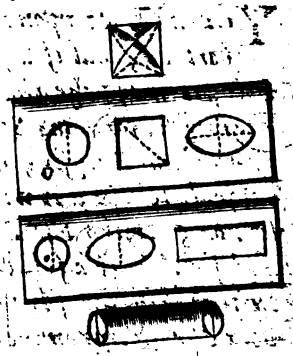


PROB.

PROBLEM. XXI.

How with one uniforme body or such like to fill three severall holes: of which the one is round, the other a just square, and the third an ovall forme?

THis Proposition seemes more subtill then the former, yet it may be practised two wayes: for the first, take a Cylindricall body as great or little as you please: Now it is evident that it will fill a Circular hole, which is made equall to the basis of it, if it be placed downe right, and will also fill a long square; whose sides are equall unto the Diameter and length of the Cylinder, and acording to *Pergæus, Archimedes, &c.* in their Cylindricall demonstrations, a true Ovall is made when a Cylinder is cut slopewise, therefore if the ovall have breadth equall unto the Diameter of the basis of the Cylinder, & any length whatsoever: the Cylinder being put into his owne Ovall hole shall also exactly fill it.



The second way is thus, make a Circular hole in some board, & also a square hole, the side of which Square may be equall to the Diameter

of the Circle: and lastly, make a hole Oval-wise, whose breadth may be equal unto the diagonall of the Square; then let a Cylindricall body be made, whose Basis may be equall unto the Circle, and the length equall also to the same: Now being placed downe right shall fall in the Circle, and flat-wise will fit the Square hole, and being placed sloping-wise will fill the Ovall.

EXAMINATION.

You may note upon the last two Problemes farther, that if a Cone be cut Ecliptick-wise, it may passe through an Isscele Triangle through many Scalen Triangles, and through an Ellipsis; and if there be a Cone cut Scalen-wise, it will passe through all the former, only for the Ellipsis place a Circle: and further, if a solid columne be cut Ecliptick-wise it may fill a Circle, a Square, divers Parallelogrammes, and divers Ellipses, which have different Diameters.

PROB.

PROBLEM XXII.

To finde a number thought upon after another manner, then what is formerly delivered

BId him that he multiply the number thought upon, by what number he pleaſeth, then bid him divide that product by any other number, and then multiply that Quotient by ſome other number; and that product againe divide by ſome other, and ſo as often as he will: and here note, that he declare or tell you by what number he did multiply & divide. Now in the ſame time take a number at pleaſure, and ſecretly multiply and divide as often as he did: then bid him divide the laſt number by that which he thought upon. In like manner do yours privately, then will the Quotient of your diviſor be the ſame with his, a thing which ſeemes admirable to thoſe which are ignorant of the cauſe. Now to have the number thought upon without ſeeming to know the laſt Quotient, bid him adde the number thought upon to it, and aske him how much it makes: then ſubtract your Quotient from it, there will remaine the number thought upon. For example, ſuppoſe the number thought upon were 5, multiply it by 4 makes 20. this divided by 2, the Quotient makes 10, which multiplyed by 6, makes 60, and divided by 4, makes 15. in the ſame time admit you think upon 4, which multiplied by 4, makes 16, this divided by 2, makes 8, which

multiplied by 6 makes 48, and divided by 4 makes 12; then divide 15 by the number thought, which was 5, the Quotient is 3; divide alſo 12 by the number you took, viz. 4, the Quotient is alſo 3, as was declared; therefore if the Quotient 3 be added unto the number thought, *viz.* 5, it makes 8, which being knowne, the number thought upon is alſo knowne.

PROBLEM XXIII.

To finde out many numbers that ſundry perſons, or one man hath thought upon.

IF the multitude of numbers thought upon be odde, as three numbers, five numbers, ſeven, &c. as for example, let 5 numbers thought upon be theſe, 2, 3, 4, 5, 6. bid him declare the ſum of the firſt and ſecond, which will be 5, the ſecond and third, which makes 7, the third and fourth, which makes 9, the fourth and fifth, which makes 11, and ſo alwayes adding the two next together, aske him how much the firſt and laſt makes together, which is 8. then take theſe ſummes, and place them in order, and adde all theſe together, which were in the odde places: that is the firſt, third, and fifth, *viz.* 5, 9, 8, makes 22. In like manner adde all theſe numbers together, which are in the even places, that is in the ſecond and fourth places, *viz.* 7, and 11 makes 18, ſubſtract this from the former 22, then there will remaine the double of the

firſt

firſt number thought upon, *viz.* 4. which known, the reſt is eaſily known: ſeeing you know the ſumme of the firſt and ſecond; but if the multitude of numbers be even as theſe ſix numbers, viz. 2,3,4,5,6,7, cauſe the partie to declare the ſumme of each two, by antecedent and conſequent, and alſo the ſumme of the ſecond and laſt, which will be 5,7,9,11,13,10, then adde the odde places together, except the firſt, that is 9, and 13, makes 22; adde alſo the even places together, that is 7,11,10, which makes 28; ſubſtract the one from the other, there ſhall remaine the double of the ſecond number thought upon, which known all the reſt are knowne.

PROBLEM XXIV.

How is it that a man in one and the ſame time, may have his head upward, and his feet upward, being in one and the ſame place?

THe anſwer is very facill, for to be ſo he muſt be ſuppoſed to be in the centre of the earth: for as the heaven is above on every ſide, *Cœlum undique ſurſum*, all that which looks to the heavens being diſtant from the centre is upward; and it is in this ſenſe that *Maurolycus* in his Cosmographie, & firſt dialogue, reported of one that thought he was led by one of the Muſes to hell, where he ſaw Lucifer ſitting in

in the middle of the World, and in the Centre of the earth, as in a Throne: having his head and feet upward.

PROBLEM. XXV.

Of a Ladder by which two men aſcending at one time; the more they aſcend, the more they ſhall be aſunder, notwithſtanding one being as high as another

THis is moſt evident, that if there were a Ladder halfe on this ſide of the Centre of the earth, and the other halfe on the other ſide: and that two at the Centre of the World at one inſtant being to aſcend, the one towards us, and the other towards our Antipodes, they ſhould in aſcending go farther and farther, one from another; notwithſtanding both of them being of like height.

PROBLEM. XXVI.

How it is that a man having but a Rod or Pole of Land, doth bragge that he may in a right line paſſe from place to place above 3000 miles.

THe opening of this is eaſie, foraſmuch as he that poſſeſſeth a Rod of ground poſſeſ-

ſeth

seth not only the exterior surface of the earth, but is master also of that which extends even to the Centre of the earth, and in this wise all heritages & possessions are as so many Pyramides, whose summets or points meet in the centre of the earth, and the basis of them are nothing else but each mans possession, field, or visible quantity; and therefore if there were made or imagined so to be made, a descent to go to the bottome of the heritage, which would reach to the centre of the earth; it would be above 3000 miles in a right line as before.

PROBLEM. XXVII.

How it is, that a man standing upright, and looking which way he will, he looketh either true North or true South.

THis happeneth that if the partie be under either of the Poles, for if he be under the North-pole, then looking any way he looketh South, because all the Meridians concurre in the Poles of the world, and if he be under the South-pole, he looks directly North by the same reason.

PROB.

PROBLEM XXVIII.

To tell any one what number remaines after certaine operations being ended, without asking any question.

BId him to think upon a number, and will him to multiply it by what number you think convenient: and to the product bid him adde what number you please, provided that ſecretly you conſider, that it may be divided by that which multiplied, and then let him divide the ſum by the number which he firſt multiplied by, and ſubſtract from this Quotient the number thought upon: In the ſame time divide apart the number which was added by that which multiplied, ſo then your Quotient ſhall be equall to his remainder, wherefore without asking him any thing, you ſhall tell him what did remaine, which will ſeem ſtrange to him that knoweth not the cauſe: for example, ſuppoſe he thought 7, which multiplied by 5 makes 35, to which adde 10; makes 45, which divided by 5, yields 9, from which if you take away one the number thought, (becauſe the Multiplier divided by the Diviſor gives the Quotient 1,) the reſt will be two, which will be alſo proved, if 10 the number which was added, were divided by 5, *viz.* 2.

PROB.

PROBLEM XXIX.

Of the play with two ſeverall things.

IT is a pleaſure to ſee and conſider how the ſcience of numbers doth furniſh us, not only with ſports, to recreate the ſpirits, but alſo bring us to the knowledge of admirable things, as ſhall in ſome meaſure be ſhewen in this enſuing progreſſion. In the meane time to produce alwayes ſome of them: ſuppoſe that a man hold divers things in his hand, as Gold and Silver, and in one hand he held the Gold, and in the other hand he held the Silver: to know ſubtilly, and by way of divination, or artificially in which hand the Gold or Silver is; attribute to the Gold, or ſuppoſe it have a certaine price, and ſo likewiſe attribute to the Silver another price, conditionally that the one be odd, and the other even: as for example, bid him that the Gold be valued at 4 Crownes, or Shillings, and the Silver at 3 Crownes, or 3 Shillings, or any other number, ſo that one be odde, and the other even, as before; then bid him triple that which is in the right hand, & double that which is in the left hand, and bid him adde theſe two products together, and aske him if it be even or odde; if it be even, then the Gold is in the right hand; if odde, the Gold is in the left hand.

PROBLEM. XXX.

Two numbers being propoſed unto two ſeverall parties, to tell which of theſe numbers is taken by each of them.

AS for example: admit you had propoſed unto two men whoſe names were *Peter* and *John*, two numbers, or pieces of money, the one even, and the other odde, as 10. and 9. and let the one of them take one of the numbers, and the other partie take the other number, which they place privately to themſelves: how artificially, according to the congruity, and excellency of numbers, to finde which of them did take 10. and which 9. without asking any queſtion: and this ſeems moſt ſubtill, yet delivered howſoever differing little from the former, and is thus performed: Take privately to your ſelfe alſo two numbers, the one even, and theother odde, as 4. and 3. then bid *Peter* that he double the number which he took, and do you privately double alſo your greateſt number; then bid *John* to triple the number which he hath, and do you the like upon your laſt number: adde your two products together, & mark if it be even or odde, then bid the two parties put their numbers together, and bid them take the halfe of it, which if they cannot do, then immediately tell *Peter* he took 10. and *John* 9. becauſe the aggregate of the double of 4. and the triple of 3. makes odde, and ſuch would

would be the aggregate or ſumme of the double of *Peters* number and *Johns* number, if *Peter* had taken 10. if otherwiſe, then they might have taken halfe, and ſo *John* ſhould have taken 10. and *Peter* 9. as ſuppoſe *Peter* had taken 10. the double is 20. and the triple of 9. the other umber is 27. which put together makes 47. odde: in like manner the double of your number conceived in minde, *viz.* 4. makes 8. and the triple of the 3. the other number, makes 9. which ſet together makes 17. odde. Now you cannot take the halfe of 17, nor 47. which argueth that *Peter* had the greater number, for otherwiſe the double of 9. is 18. & the triple of 10. is 30. which ſet together makes 48. the halfe of it may be taken: therefore in ſuch caſe *Peter* the took leſſe number: and *John* the greater, and this being don cleanly carries much grace with it.

Problem. XXXI.

How to deſcribe a Circle that ſhall touch 3: Points placed howſoever upon a plaine, if they be not in a right line:

LEt the three points be *A. B. C.* put one foot of the Compaſſe upon *A.* and deſcribe an Arch of a Circle at pleaſure: and placed at *B.* croſſe that Arch in the two points *E.* and *F.* and placed in *C.* croſſe the Arch in *G.* and *H.* then lay a ruler upon *G. H.* and draw a line, and

place

place a Ruler upon *B.* and *F.* cut the other line in *K*, ſo *K.* is the Centre of the Circumference of a Circle, which will paſſe by the ſaid three points *A. B. C.* or it may be inverted, having a Circle drawne; to finde the Centre of that Circle, make

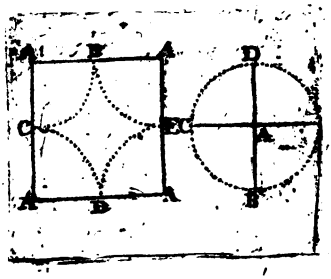
3. points in the circumference, and then uſe the ſame way: ſo ſhall you have the Centre, a thing moſt facill to every practitioner in the principles of Geometrie.

PROBLEM. XXXII.

How to change a Circle into a ſquare forme?

MAke a Circle upon paſt-board or other materiall, as the Circle *A. C. D. E.* of which *A.* is the Centre; then cut it into 4. quarters, and diſpoſe them ſo, that *A.* at the centre of the Circle may alwayes be at the *Angle* of the ſquare, and ſo the foure quarters of the Circle

Circle being placed ſo, it will make a perfect ſquare, whoſe ſide *A. A.* is equall to the Diameter *B. D.* Now here is to be noted that the ſquare is greater then the Circle by the vacuity in the middle, *viz. M.*

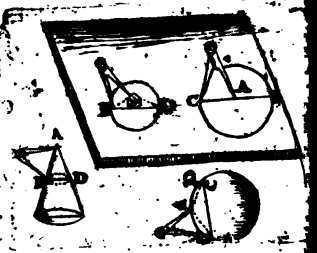


PROBLEM. XXXIII.

With one and the ſame compaſſes, and at one and the ſame extent, or opening, how to deſcribe many Circles concentricall, that is, greater or leſſer one then another?

IT is not without cauſe that many admire how this Propoſition is to be reſolved; yea in the judgement of ſome it is thought impoſſible: who conſider not the induſtrie of an ingenious Geometrician, who makes it poſſible, and that moſt facill, ſundry wayes; for in the firſt place if you make a Circle upon a fine plaine, and upon the Centre of that Circle, a ſmall pegge of wood be placed, to be raiſed up and put downe at pleaſure by help of a ſmall hole made in the Centre, then with the ſame opening of the Compaſſes, you may deſcribe Circles Concentricall, that is, one greater or leſſer than another; for the higher the Center is lifted up, the

leſſer the Circle will be. Secondly, the compaſſe being at that extent upon a *Gibus* body, a Circle may be deſcribed, which will be leſſe than the former, upon a plaine, and more artificially upon a Globe, or round bowle: and this againe is moſt obvious upon a round Pyramide, placing the Compaſſes upon the top of it, which will be farre leſſe than any of the former; and this is demonſtrated by the 20. Prop. of the firſt of *Euclids*, for the Diameter *E D.* is leſſe than the line *A D. A E.* taken together, and the lines *A D. A E.* being equall to the Diameter *B C.* becauſe of the ſame diſtance or extent of opening the compaſſes, it followes that the Diameter *E D.* and all his Circles together is much leſſe than the Diameter, and the Circle *B C.* which was to be performed.



PROB.

PROBLEM XXXIV.

Any numbers under 10. *being thought upon, to finde what numbers they were.*

LEt the firſt number be doubled, and unto it adde 5. and multiply that ſumme by 5. and unto it adde 10. and unto this product add the next number thought upon; multiply this ſame againe by 10. and adde unto it the next number, and ſo proceed: now if he declare the laſt ſumme; marke, if he thought but upon one figure, for then ſubtract only 35. from it, and the firſt figure in the place of tennes is the number thought upon: if he thought upon two figures, then ſubtract alſo the ſaid 35. from his laſt ſumme, and the two figures which remaine are the number thought upon: if he thought upon three figures, then ſubtract 350. and then the firſt three figures are the numbers thought upon, &c. ſo if one thought upon theſe numbers 5.7.9.6. double the firſt, makes 10. to which adde 5. makes 15. this multiplied by 5. makes 75. to which adde 10. makes 85. to this adde the next number, *viz.* 7. makes 92. this multiplied by 10. makes 920. to which adde the next number, *viz.* 9. makes 929. which multiplied by 10. makes 9290. to which adde 6. makes 9296. from which ſubtract 3500. reſteth 5796. the foure numbers thought upon. Now becauſe the two laſt figures are like the two numbers thought

upon: to conceale this, bid him take the halfe of it, or put first 12. or any other number to it, and then it will not be so open.

PROBLEM. XXXV.

Of the Play with the Ring.

AMongst a company of 9. or 10. persons, one of them having a Ring, or such like: to finde out in which hand: upon which finger, & joynt it is; this will cause great astonishment to ignorant spirits, which will make them beleeve that he that doth it works by Magick, or Witchcraft: But in effect it is nothing else but a nimble act of Arithmetick, founded upon the precedent Probleme: for first it is supposed that the persons stand or sit in order, that one is first, the next second, &c. likewise there must be imagined that of these two hands the one is first, and the other second: and also of the five fingers, the one is first, the next is second, and lastly of the joynts, the one is as 1. the other is as 2. the other as 3. &c. from whence it appeares that in performing this Play there is nothing else to be done than to think 4. numbers: for example, if the fourth person had the Ring in his left hand, and upon the fifth finger, and third joynt, and I would divine and finde it out: thus I would proceed, as in the 24 Problem: in causing him to double the first number: that is, the number of persons

sons

ſons, which was 4. and it makes 8. to which add 5. makes 13. this multiplied by 5. makes 65. put 10. to it, makes 75. unto this put 2. for the number belonging to the left hand, and ſo it makes 77. which multiplied by 10. makes 770. to this adde the number of the fingers upon which the Ring is, *viz.* 5. makes 775. this multiplied by 10. makes 7750. to which adde the number for the joynt upon which the Ring is, *viz.* the third joynt, makes 7753. to which cauſe him to adde 14. or ſome other number, to conceale it the better: and it makes 7767. which being declared unto you, ſubſtract 3514. and there will remaine 4.2.5.3. which figures in order declares the whol myſtery of that which is to be known: 4. ſignifieth the fourth perſon, 2. the left hand, 5. the fifth finger, and 3. the third joynt of that finger.

PROBLEM. XXXVI.

The Play of 34. or more Dice.

THat which is ſaid of the two precedent Problemes may be applied to this of Dice (and many other particular things) to finde what number appeareth upon each Dice being caſt by ſome one, for the points that are upon any ſide of a Dice are alwayes leſſe than 10 and the points of each ſide of a Dice may be taken for a number thought upon: therefore the Rule will be as the former: As for example, one ha-

ving thrown three Dice, and you would declare the numbers of each one, or how much they make together, bid him double the points of one of the Dice, to which bid him adde 5, then multiply that by 5. and to it adde 10, and to the ſumme bid him adde the number of the ſecond Dice: and multiply that by 10: laſtly, to this bid him adde the number of the laſt Dice, and then let him declare the whole number: then if from it you ſubtract 350 there will remaine the number of the three Dice throwne.

PROBLEM. XXXVII.

How to make water in a Glaſſe ſeeme to boyle and ſparkle?

TAke a Glaſſe neere full of water or other liquor; and ſetting one hand upon the foot of it, to hold it faſt: turne ſlightly one of the fingers of your other hand upon the brimme, or edge of the Glaſſe; having before privately wet your finger: and ſo paſſing ſoftly on with your finger in preſſing a little: for then firſt, the Glaſſe will begin to make a noyſe: ſecondly, the parts of the Glaſſe will ſenſibly appeare to tremble, with notable *rarefaction* and *condenſation*: thirdly, the water will ſhake, ſeeme to boyle: fourthly, it will caſt it ſelfe out of the Glaſſe, and leap out by ſmall drops, with great aſtoniſhment to the ſtanders by; if they be ignorant of the cauſe of it, which

is

is onely in the Rarefaction of the parts of the Glaſſe, occaſioned by the motion and preſſure of the finger.

EXAMINATION.

THe cauſe of this, is not in the rarefaction of the parts of the Glaſſe, but it is rather in the quick locall motion of the finger, for reaſon ſheweth us that by how much a Body draweth nearer to a quality, the leſſe is it ſubject or capable of another which is contrary unto it? now condenſation, and rarefaction are contrary qualities, and in this Probleme there are three bodies conſidered, the Glaſſe, the Water, and the Aire, now it is evident that the Glaſſe being the moſt ſolid, and impenitrable Body, is leſſe ſubject and capable of rarefaction than the water, the water is leſſe ſubject than the Aire, and if there be any rarefaction, it is rather conſiderable in the Aire then in the Water, which is inſcribed by the Glaſſe, and above the Water, and rather in the Water then in the Glaſſe: the agitation, or the trembling of the parts of the Glaſſe to the ſenſe appeares not: for it is a continued body; if in part, why then not in the whole? and that the Water turnes in the Glaſſe, this appeares not, but only the

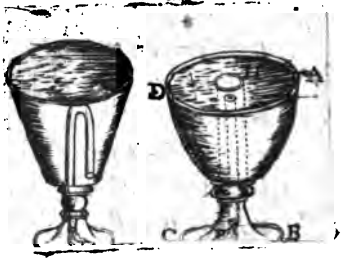
upper contiguous parts of the Water: that at the bottome being leſſe ſubiect to this agitation, and it is moſt certaine that by how much quicker the Circular motion of the finger upon the edge of the Glaſſe is, by ſo much the more ſhall the Aire be agitated, and ſo the water ſhall receive ſome apparant affection more or leſſe from it, according to that motion: as we ſee from the quickneſſe of winde upon the Sea, or calme thereof, that there is a greater or leſſer agitation in the water; and for further examination, we leave it to the ſearch of thoſe which are curious.

PROBLEM. XXXVIII.

Of a fine veſſell which holds wine or water, being caſt in'to it at a certaine height, but being filled higher, it will runne out of its owne accord.

LEt there be a veſſell *A.B.C.D.* in the middle of which place a Pipe; whoſe ends both above at *E*, and below at the bottom of the veſſell as at *F*, are open; let the end *E* be ſomewhat lower than the brimme of the Glaſſe: about this Pipe, place another Pipe as *H. L*, which mounts a little above *E*, and let it moſt diligently be cloſed at *H*, that no Aire enter in thereby, and this Pipe at the bottome may have a ſmall hole to give paſſage unto the water; then

then poure in water or wine, and as long as it mounts not above *E*, it is safe; but if you poure in the water so that it mount above it, farewell all; for it will not cease untill it be all gone out; the same may be done in disposing any crooked Pipe in a vessell in the manner of a Faucet or funnell, as in the figure *H*, for fill it under *H*, at pleasure, and all will go well; but if you fill it unto *H*. you will see fine sport, for then all the vessell will be empty incontinent, and the subtilty of this will seeme more admirable, if you conceale the Pipe by a Bird, Serpent, or such like, in the middle of the Glasse. Now the reason of this is not difficult to those which know the nature of a Cock or Faucet; for it is a bowed Pipe, one end of which is put into the water or liquor, and sucking at the other end untill the Pipe be full, then will it run of it selfe, and it is a fine secret in nature to see, that if the end of the Pipe which is out of the water, be lower then the water, it will run out without ceasing: but if the mouth of the Pipe be higher then the water or levell with it, it will not runne, although the Pipe which is without be many times bigger than that which is in the water: for it is the property of water to keep alwayes exactly levell,



EXAM-

EXAMINATION.

HEre is to be noted, that if the face of the water without be in one and the ſame plaine, with that which is within, though the outtermoſt Pipe be ten times greater than that which is within; the water naturally will not runne, but if the plaine of the water without be any part lower then that which is within, it will freely runne: and here may be noted further, that if the mouth of the Pipe which is full of water, doth but only touch the ſuperficies of the water within, although the other end of the pipe without be much lower than that within, the water it will not run at all: which contradicts the firſt ground; hence we gather that the preſſure or ponderoſity of the water within, is the cauſe of running in ſome reſpect.

PROBLEM. XXXIX.

Of a Glaſſe very pleaſant.

SOmetimes there are Glaſſes which are made of a double faſhion, as if one Glaſſe were within another, ſo that they ſeem but one, but there is a little ſpace between them. Now poure Wine or other liquor between the two edges,

edges by help of a Tunnell, into a little hole left to this end, ſo vvill there appeare tvvo fine deluſions or fallacies; for though there be not a drop of Wine vvithin the hollovv of the Glaſſe, it vvill ſeem to thoſe vvhich behold it that it is an ordinary Glaſſe full of Wine, and that eſpecially to thoſe vvhich are ſide-vviſe of it, and if any one move it, it vvill much confirme it, becauſe of the motion of the Wine; but that vvhich vvill give moſt delight, is that, if any one ſhall take the Glaſſe, and putting it to his mouth ſhall think to drink the Wine, inſtead of vvhich he ſhall ſup the Aire, and ſo vvill cauſe laughter to thoſe that ſtand by, vvho being deceived, vvill hold the Glaſs to the light, & thereby conſidering that the raies or beames of the light are not reflected to the eye, as they vvould be if there vvere a liquid ſubſtance in the Glaſſe, hence they have an aſſured proofe to conclude, that the hollovv of the Glaſſe is totally empty.

PROBLEM. XI.

If any one ſhould hold in each hand, as many pieces of money as in the other, how to finde how much there is?

BId him that holds the money that he put out of one hand into the other vvhat number you think convenient: (provided that it may be done,) this done, bid him that out of the hand that he put the other number into, that he take

take out of it as many as remaine in the other hand, and put it into that hand: for then be assured that in the hand which was put the first taking away: there will be found just the double of the number taken away at the first. Example, admit there were in each hand 12 Shillings or Counters, and that out of the right hand you bid him take 7. and put it into the left: and then put into the right hand from the left as many as doth remaine in the right, which is 5. so there will be in the left hand 14, which is the double of the number taken out of the right hand, to wit 7. then by some of the rules before delivered, it is easie to finde how much is in the right hand, *viz.* 10.

PROBLEM. XLI.

Many Dice being cast, how artificially to discover the number of the points that may arise.

SVppose any one had cast three Dice secretly, bid him that he adde the points that were uppmost together: then putting one of the Dice apart, unto the former summe adde the points which are under the other two, then bid him throw these two Dice, and mark how many points a paire are upwards, which adde unto the former summe: then put one of these Dice away not changing the side, mark the points which are under the other Dice, and adde it to the

the former ſumme: laſtly, throw that one Dice, and whatſoever appeares upward adde it unto the former ſumme; and let the Dice remaine thus: this done, comming to the Table, note what points do appeare upward upon the three Dice, which adde privately together, and unto it adde 21 or 3 times 7: ſo this Addition or ſumme ſhall be equall to the ſumme which the party privately made of all the operations which he formerly made. As if he ſhould throw three Dice, and there ſhould appeare upward 5, 3, 2. the ſum of them is 10. and ſetting one of them apart, (as 5.) unto 10, adde the points which are under 3 and 2, which is 4 and 5, and it makes 19. then caſting theſe two Dice ſuppoſe there ſhould appeare 4 and 1, this added unto 19 makes 24. and ſetting one of theſe two Dice apart as the 4. unto the former 24, I adde the number of points which is under the other Dice, *viz.* under 1, that is 6, which makes 30. Laſt of all I throw that one Dice, and ſuppoſe there did appeare 2, which I adde to the former 30, and it makes 32, then leaving the 3 dice thus, the points which are upward will be theſe, 5, 4, 2 unto which adde ſecretly 21, (as before was ſaid) ſo have you 32, the ſame number which he had; and in the ſame manner you may practiſe with 4, 5, 6, or many Dice or other bodies, obſerving only that you muſt adde the points oppoſite of the Dice; for upon which depends the whole demonſtration or ſecret of the play; for always that which is above and under-

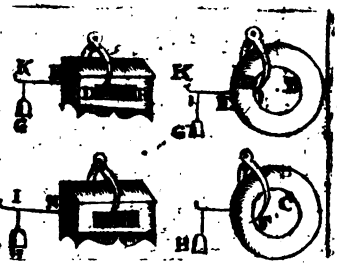
underneath makes 7. but if it make another number, then muſt you adde as often that number.

PROBLEM. XLII.

Two metals, as Gold and Silver, or of other kinde weighing alike, being privately placed into two like Boxes, to finde which of them the Gold or Silver is in.

IT is ſaid that an Emperour was requeſted by one of his ſervants after he had long time remained with him, to aſſigne him ſome reward: to which after few dayes the Emperour condeſcended, and cauſed him to come into his Treaſury, where he had prepared two Boxes; one full of Gold, and the other full of Lead, both weighing, and of forme and magnitude alike: and bid him chuſe which he would have. Now many think that in this Probleme one muſt be guided only by fortune in this choiſe, and it is that which moſt makes a man happy in ſuch a choiſe: but the want of knowledge cauſeth them ſo to judge which know not otherwiſe. A Mathematician accounts it an eaſie propoſition, & will infallibly chuſe the cheſt of Gold, and leave the cheſt of Lead, without either breaking, or opening any of the cheſts, and not go by chance and fortune: for if he may be permitted to weigh thoſe cheſts firſt in the Aire, then in the water: it is a thing cleare by the

the proportion of Mettalls, & according to the principles of *Archimedes*, that the Gold ſhal be leſſe weighty by his eighteenth part, & the Lead by his 11th part, wherefore there may be gathered in which is the Gold, and in which is the Lead.



But becauſe that this experiment in water hath divers accidents, and therefore ſubject to a caution; and namely, becauſe the matter of the cheſt, mettall or other things may hinder.

Behold here a more ſubtill and certaine invention to finde and diſcover it out without weighing it in the water: Now experience and reaſon ſheweth us that two like bodies or magnitudes of equall weight, and of divers mettalls, are not of equal quantity: and ſeeing that Gold is the heavieſt of all mettalls, it will occupie leſs roome or place; from which will follow that the like weight of Lead in the ſame forme, will occupie or take up more roome or place. Now let there be therefore preſented two Globes or Cheſts of wood or other matter alike, & equall one to the other, in one of which in the middle there is another Globe or body of lead weighing 12. l. (as *C*,) and in the other a Globe or like body of Gold weighing 12 pound (as *B*.) Now it

it is ſuppoſed that the wooden Globes or Cheſts are of equall weight, forme, and magnitude: and to diſcover in which the Gold or Lead is in, take a broad paire of Compaſſes, and clip one of the Coffers or Globes ſomewhat from the middle, as at *D*. then fix in the Cheſt or Globe a ſmall piece of Iron betweene the feet of the Compaſſes, as *E K*, at the end of which hang a vveight *G*, ſo that the other end may be counterpoyſed, and hang *in æquilibrio*: and do the like to the other Cheſt or Globe. Now if that the other Cheſt or Globe being clipped in like diſtance from the end, and hanging at the other end the ſame weight *G*. there be found no difference; then clip them nearer towards the middle, that ſo the points of the Compaſſe may be againſt ſome of the mettall vvhich is incloſed; or juſt againſt the extremitie of the Gold as in *D*, and ſuppoſe it hang thus in *æquilibrio*; it is certaine that in the other Coffer is the Lead; for the points of the Compaſſes being advanced as much as before, as at *F*, vvhich takes up a part of the Lead, (becauſe it occupies a greater place than the Gold) therefore that ſhall help the vveight *G*. to vveigh, and ſo vvill not hang in *æquilibrio*, except *G*. be placed neare to *F*. hence vve may conclude, that there is the Lead; and in the other Cheſt or Globe, there is the Gold.

EXAMINATION.

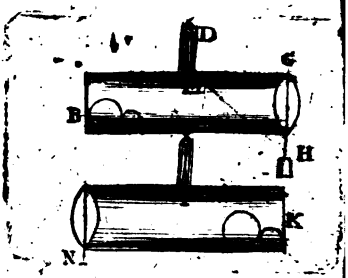
IF the two Boxes being of equall magnitude weighed in the aire be found to be of equall weight, they ſhall neceſſarily take up like place in the water, and therefore weigh alſo one as much as another: hence there is no poſſibilitie to finde the inequalitie of the mettalls which are incloſed in theſe Boxes in the water: the intention of Archimedes *was not upon contrary mettalls incloſed in equall Boxes, but conſiſted of comparing mettalls, ſimple in the water one with another: therefore the inference is falſe and abſurd.*

PROBLEM. XLIII.

Two Globes of diverſe mettalls, (as one Gold, and the other Copper) yet of equall weight being put into a box, as BG, to finde in which end the Gold or Copper is.

THis is diſcovered by the changing of the places of the two Bowles or Globes, having the ſame counterpoyſe *H* to be hung at the other ſide, as in *N*. and if the Gold which is the leſſer Globe, were before the neareſt to the handle *DE*, having now changed his place will be fartheſt from the handle *DE*, as in *K*.

therefore the Centre of gravity of the two Globes taken together, shall be farther separate from the middle of the handle (under which is the Centre of gravity of the Box) than it was before, and seeing that the handle is alwayes in the middle of the Box, the vveight *N.* must be augmented, to keep it in *equilibrio*: and by this way one may knovv, that if at the second time, the counterpoise be too light, it is a signe that the Gold is fartheſt off the handle, as at the firſt triall it vvas neareſt.



PROBLEM. XLIII.

How to represent divverſe ſorts of Rainebowes here below?

THe Rainbovve is a thing admirable in the vvorld, vvhich raviſheth often the eyes and ſpirits of men in conſideration of his rich intermingled colours vvhich are ſeen under the clouds, ſeeming as the gliſtering of the Starres, precious ſtones, and ornaments of the moſt beauteous flovvers: ſome part of it as the reſplendent ſtars, or as a Roſe, or burning Cole of fire. in it one may ſee Dyes of ſundry ſorts, the

the Violet, the Blew, the Orange, the Saphir, the Jacinct, and the Emerald colours, as a lively plant placed in a green soile: and as a most rich treasure of nature, it is a high work of the Sun who casteth his raies or beames as a curious Painter drawes strokes with his pensill, and placeth his colours in an exquisite situation; and *Solomon* saith, *Eccles.* 43. it is a chiefe and principall work of God. Notwithstanding there is left to industrie how to represent it from above, here below, though not in perfection, yet in part, with the same intermixture of colours that is above.

Have you not seen how by Oares of a Boate it doth exceeding quickly glide upon the water with a pleasant grace? *Aristotle* sayes, that it coloureth the water, and makes a thousand atomes, upon which the beames of the Sunne reflecting, make a kinde of coloured Rainbowe: or may we not see in houses or Gardens of pleasure artificiall fountaines, which poure forth their droppie streames of water, that being between the Sunne and the fountaine, there will be presented as a continuall Rainbowe? But not to go farther, I will shew you how you may do it at your doore, by a fine and facill experiment.

Take water in your mouth, and turne your back to the Sunne, and your face against some obscure place, then blow out the water which is in your mouth, that it may be sprinkled in small drops and vapours: yon shall see those

atomes vapours in the beames of the Sunne to turne into a faire Rainebowe, but all the griefe is, that it lasteth not, but soone is vanished.

But to have one more stable and permanent in his colours: Take a Glasse full of water, and expose it to the Sunne, so that the raies that passe through strike upon a shadowed place, you will have pleasure to see the fine forme of a Rainebovve by this reflection. Or take a Trigonall Glasse or Crystall Glasse of diverse Angles, and look through it, or let the beames of the Sunne passe through it; or vvith a candle let the appearances be received upon a shaded place: you vvill have the same contentment.

PROBLEM XLV.

How that if all the Powder in the world were inclosed within a bowle of paper or glasse, and being fired on all parts, it could not break that bowle?

IF the bowle and the powder be uniforme in all his parts, then by that means the powder would presse and move equally on each side, in which there is no possibility whereby it ought to begin by one side more than another. Now it is impossible that the bowle should be broken in all his parts: for they are infinite.

Of like fineness or subtiltie may it be that a bowle of Iron falling from a high place upon a plaine pavement of thin Glasse, it were impossible

ſible any wiſe to break it; if the bowle were perfectly round, and the Glaſſe flat and uniforme in all his parts. for the bowle would touch the Glaſſe but in one point, which is in the middle of infinite parts which are about it: neither is there any cauſe why it ought more on one ſide than on another, ſeeing that it may not be done with all his ſides together; it may be concluded as ſpeaking naturally, that ſuch a bovvle falling upon ſuch a glaſſe vvill not break it. But this matter is meere Metaphyſicall, and all the vvorkmen in the vvorld cannot ever vvith all their induſtrie make a bovvle perfectly round, or a Glaſſe uniforme.

PROBLEM. XLVI.

To finde a number which being divided by 2, there will remaine 1, being divided by 3, there will remaine 1; and ſo likewiſe being divided by 4, 5, or 6, there would ſtill remaine 1; but being divided by 7, there will remaine nothing.

IN many Authors of Arithmetick this Probleme is thus propoſed: A vvoman carrying Egges to Market in a basket, met an unruly fellovv who broke them: who vvas by order made to pay for them: and ſhe being demanded what number ſhe had, ſhe could not tell: but ſhe remembred

membred that counting them by 2 & 2, there remained 1. likewiſe by 3 and 3 by 4 and 4, by 5 and 5, by 6 and 6; there ſtill remained 1, but when ſhe counted them by 7 and 7, there remained nothing: Now how may the number of Egges be diſcovered?

Finde a number which may exactly be meaſured by 7, and being meaſured by 2,3,4,5, and 6; there vvill ſtill remaine a unite: multiply theſe numbers together, makes 720, to which adde 1; ſo have you the number, *viz.* 721. in like manner 301 vvill be meaſured by 2,3,4,5, 6, ſo that 1 remaines: but being meaſured by 7, nothing vvill remaine; to vvhich continually adde 220, and you have other numbers vvhich vvill do the ſame: hence it is doubtfull vvhat number ſhe had, therefore not to faile, it muſt be knovvn vvhether they did exceed 400, 800, &c. in vvhich it may be conjectured that it could not exceed 4 or 5 hundred, ſeeing a man or vvoman could not carry 7 or 8 hundred Egges, therefore the number vvas the former 301. vvhich ſhe had in her Basket: vvhich being counted by 2 and 2, there vvill remaine 1, by 3 and 3, &c. but counted by 7 and 7, there vvill remaine nothing.

PROB.

PROBLEM. XLVII.

One had a certaine number of crownes, and counting them by 2 and 2, there reſted 1. counting them by 3 and 3, there reſted 2. counting them by 4 and 4, there reſted 3. counting them by 5 and 5, there reſted 4. counting them by 6 & 6, there reſted 5. but counting them by 7 and 7, there remained nothing: how many crownes might he have?

THis Queſtion hath ſome affinitie to the precedent, and the reſolution is almoſt in the ſame manner: for here there muſt be found a number, vvhich multiplied by 7, and then dividedby 2,3,4,5,6; there may alvvayes remaine a nuumber leſſe by 1 than the Diviſor: Novv the firſt number vvhich arrives in this nature is 119, unto vvhich if 420 be added, makes 539, vvhich alſo vvill do the ſame: and ſo by adding 420, you may have other numbers to reſolve this propoſition.

PROBLEM. XLVIII.

How many ſorts of weights in the leaſt manner muſt there be to weigh all ſorts of things between 1 pound and 40 pound, and ſo unto 121, & 364 pound.

TO vveigh things betvveen 1 and 40, take numbers in triple proportion, ſo that their

ſumme be equall, or ſomewhat greater than 40, as are the numbers 1. 3. 9. 27. I ſay that with 4 ſuch weights, the firſt being of 1 pound, the ſecond being 3 pound, the third being 9 pound, and the fourth being 27: any weight between 1 and 40 pound may be weighed. As admit to weigh 21 pound, put unto the thing that is to be weighed the 9 pound weight, then in the other ballance put 27 pound and 3 pound, which doth counterpoiſe 21 pound and 9 pound, and if 20 pound were to be weighed, put to it in the ballance 9 and 1, and in the other ballance put 27 and 3, and ſo of others.

In the ſame manner take thoſe 5 weights, 1, 3, 9, 27, 81, you may weigh with them between 1 pound, and 121 pound: and taking thoſe 6 weights, as 1, 3, 9, 27, 81, 243, you may weigh even from 1 pound unto 364 pound: this depends upon the property of continued proportionals, the latter of which containing twice all the former.

PROBLEM. XLIX.

Of a deceitfull ballance which being empty ſeemes to be juſt, becauſe it hangs in aquilibrio: notwithſtanding putting 12 pound in one ballance, and 11 in the other, it will remaine in aquilibrio.

ARiſtotle maketh mention of this ballance in his mechanick Queſtions, and ſaith, that the

the Merchants of purpoſe in his time uſed them to deceive the world: the ſubtilty or craft of which is thus, that one arme of the ballance is longer then another, by the ſame proportion, that one weight is heavier then another: As if the beame were 23 inches long, and the handle placed ſo that 12 inches ſhould be on one ſide of it, and 11 inches on the other ſide: conditionally that the ſhorter end ſhould be as heavy as the longer, a thing eaſie to be done: then afterwards put into the ballance two unequal weights in ſuch proportion as the parts of the beame have one unto another, which is 12 to 11, but ſo that the greater be placed in the ballance which hangs upon the ſhorter part of the beame, and the leſſer weight in the other ballance: it is moſt certaine that the ballances will hang *in æquilibrio*, which will ſeem moſt ſincere and juſt; though it be moſt deceitfull, abominable, and falſe.

The reaſon of this is drawne from the experiments of *Archimedes*, who ſhewes that two unequall weights will counterpoyſe one another, when there is like proportion betweene the parts of the beame (that the handle ſepa-

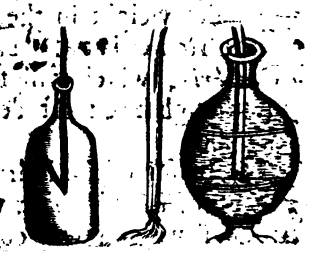
rates)

rates and the vveights themſelves: for in one and the ſame counterpoiſe, by hovv much it is farther from the Centre of the handle, by ſo much it ſeems heavier, therefore if there be a diverſitie of diſtance that the ballances hang from the handle, there muſt neceſſarily be an inequality of weight in theſe ballances to make them hang in *æquilibrio*, and to diſcover if there be deceit, change the weight into the other ballance, for as ſoone as the greater vveight is placed in the ballance that hangs on the longer parts of the beame: it vvill vveigh dovvne the other inſtantly.

PROBLEM. L.

To heave or lift up a bottle with a ſtraw.

TAke a ſtravv that is not bruiſed, bovv it that it make an Angle, and put it into the bottle ſo that the greateſt end be in the neck, then the Reed being put in the bovved part vvill caſt ſide-vviſe, and make an Angle as in the figure may be ſeen: then may you take the end vvhich is out of the bottle in your hand, and heave up the bottle,



and

and it is so much surer, by how much the Angle is acuter or sharper; and the end which is bowed approacheth to the other perpendicular parts which come out of the bottle.

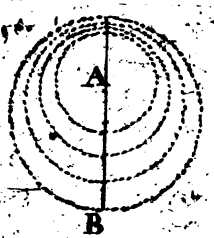
Problema LI.

How in the middle of a wood or desert, without the sight of the Sunne, Starres, Shadow or Compasse, to finde out the North or South, or the foure Cardinall points of the world, East, West, &c.

IT is the opinion of some, that the windes are to be observed in this: if it be hot, the South is found by the windes that blow that way, but this observation is uncertaine and subject to much error: nature will help you in some measure to make it more manifest than any of the former, from a tree thus: Cut a small tree off, even to the ground, and mark the many circles that are about the sap or pith of the tree, which seem nearer together in some part than in other, which is by reason of the Suns motion about the tree: for that the humiditie of the parts of the tree towards the South by the heat of the Sun, is rarified, and caused to extend: and the Sun not giving such heat towards the North-part of the tree, the sap is lesser rarefied, but condensed; by which the circles are nearer together on the North-part, than on the South-part: therefore if a line be drawne from the

widest

wideſt to the narroweſt part of the circles, it ſhall ſhew the North & South of the world. Another Experiment may be thus: Take a ſmall needle, ſuch as women work with: place it gently downe flatwiſe upon ſtill water, and it will not ſink,



(which is againſt the generall tenet that Iron will not ſwimme) which needle will by little and little turne to the North and South-points. But if the needle be great and will not ſwim, thruſt it through a ſmall piece of Cork, or ſome ſuch like thing, and then it will do the ſame: for ſuch is the property of Iron when it is placed *in æquilibrio*, it ſtrives to finde out the Poles of the world or points of North and South in a manner as the *Magner* doth.

EXAMINATION.

HEre is obſervable, that the moiſture which aideth to the growth of the tree, is rarefied and rarefied by the Meridionall heat, and contracted by the Septentrionall *cold: this rarefaction works upon the part of the humour or moiſture that is more thinne, which doth eaſily diſſipate and evaporate: which evape-*

evaporation carries a part of the ſalt with it; and becauſe that ſolidation or condenſation, ſo that there is left but a part of the nouriſhment which the heat bakes up and conſumes: ſo contrarily on the other ſide the condenſation and reſtrictive quality of the moiſture cauſeth leſſe evaporation and perdition: and ſo conſequently there remaines more nouriſhment, which makes a greater increaſe on that ſide than on the other ſide: for as trees have their growth in winter, becauſe of their pores and theſe of the earth are ſhut up: ſo in the ſpring when their pores are open, and when the ſappe and moiſture is drawne by it, there is not ſuch cold on the North-ſide that it may be condenſed at once: But contrarily to the ſide which is South, the heat may be ſuch, that in little time by continuance, this moiſture is diſſipated greatly: and cold is nothing but that which hardneth and contracteth the moiſture of the tree, and ſo converteth it into wood.

Problem. LII.

Three perſons having taken Counters, Cards, or other things, to finde how much each one hath taken.

CAuſe the third party to take a number which may be divided by 4, and as often as he takes 4, let the ſecond party take 7, and the first

firſt take 13, then cauſe them to put them all together, and declare the ſumme of it; which ſecretly divide by 3, and the Quotient is the double of the number which the third perſon did take. Or cauſe the third to give unto the ſecond and firſt, as many as each of them hath; then let the ſecond give unto the firſt and third, as many as each of them hath; laſtly, let the third give unto the ſecond and firſt, as many as each of them hath; and then aske how much one of them hath: (for they will have then all alike,) ſo halfe of that number is the number that the third perſon had at the firſt: which knowne all is knowne.

PROBLEM. LIII.

How to make a conſort of muſick of many parts with one voyce, or one inſtrument only?

THis Probleme is reſolved, ſo that a ſinger or player upon an inſtrument, be neare an Echo which anſwereth his voice or inſtrument; and if the Echo anſwereth but once at a time, he may make a double; if twice, then a triple, if three times, then an harmonie of foure parts, for it muſt be ſuch a one that is able to exerciſe both tune and note as occaſion requires. As when he begins *re*, before the Echo anſwer, he may begin *ſol*, and pronounce it in the ſame tune that the Echo anſwereth, by which meanes you have a fifth, agreeable conſort of muſick: then

in

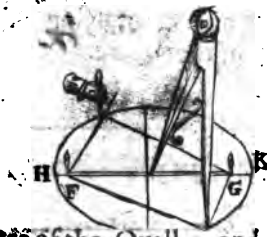
in the ſame time that the Echo followeth, to ſound the ſecond note *ſol*, he may ſound forth another *ſol* higher or lower to make an eight, the moſt perfect conſort of muſick, and ſo of others, if he will continue his voice with the Echo, and ſing alone with two parts. Now experience ſheweth this to be true, which often comes to paſſe in many Churches, making one to beleeve that there are many more parts in the muſick of a Quire, then in effect truly there are becauſe of the reſounding and multiplying of the voice, and redoubling of the Quire.

PROBLEM. LIIII.

To make or deſcribe an Ovall forme, or that which neare reſembles unto it, alone turning with a paire of common Compaſſes.

THere are many fine wayes in Geometricall practices, to make an Ovall figure or one neare unto it, by ſeverall centres: any of which I will not touch upon, but ſhew how it may be done promptly upon one centre only. In which I will ſay nothing of the Ovall forme, which appeares, when one deſcribeth circles with the points of a common Compaſſes, ſomewhat deep upon a skinne ſtretched forth hard: which contracting it ſelfe in ſome parts of the skinne maketh an Ovall forme. But it will more evidently appeare upon a Columne or Cylinder: if paper

per be placed upon it, then with a paire of Compaſſes deſcribe as it were a circle upon it, which paper afterwards being extended, will not be circular but ovall-wiſe: and a paire of Compaſſes may be ſo accommodated, that it may be done alſo upon a plaine thus. As let the length of the Ovall be *H. K*, faſten 2 pinnes or nailes neare the end of that line as *F.G*, and take a threed which is double to the length of *G.H*, or *F. K*, then if you take a Compaſſe which may have one foot lower than another, with a ſpring between his legges: and placing one foot of this Compaſſe in the Centre of the Ovall, and guiding the threed by the other foot of the Compaſſes, and ſo carrying it about: the ſpring will help to deſcribe and draw the Ovall forme. But in ſtead of the Compaſſes it may be done with ones hand only, as in the figure may appeare.

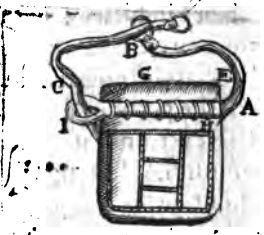


PROBLEM. LV.

Of a purſe difficult to be opened.

IT is made to ſhut and open with Rings: firſt at each ſide there is a ſtrap or ſtring, as *A B*, and

and *C D*, at the end of which are 2 rings, *B* & *D*, and the ſtring *C D* paſſeth through the ring *B*, ſo that it may not come out againe; or be parted one from another: and ſo that the ring *B*, may ſlide up and downe upon the ſtring *C D*, then over the purſe, there is a piece of Leather *E F G H*, which covers the opening of the purſe, and there is another piece of Leather *A E*, which paſſeth through many rings: which hath a ſlit towards the end *I*, ſo great that the ſtring *B C* may ſlide into it: Now all the cunning or craft is how to make faſt or to open the purſe, which conſiſts in making the ſtring *B C* ſlide through the ſide at *I*, therefore bring down *B* to *I*, then make the end *I* paſſe through the ring *B*, and alſo *D* with his ſtring to paſſe through the ſlit *I*, ſo ſhall the purſe be faſt, and then may the ſtrings be put as before, and it will ſeem difficult to diſcover how it was done. Now to open the purſe, put through the end *I* through the ring *B*, and then through the ſlit *I*, by which you put through the ſtring *D C*, by this way the purſe will be opened.



PROBLEM. LVI.

Whether it is more hard and admirable without Compasses to make a perfect circle, or being made to finde out the Centre of it?

IT is said that upon a time past, two Mathematicians met, and they would make tryall of their industry: the one made instantly a perfect circle without Compasses, and the other immediately pointed out the Centre thereof with the point of a needle; now which is the chiefest action? it seems the first, for to draw the most nobleſt figure upon a plaine Table without other help than the hand, and the minde, is full of admiration; to finde the Centre is but to finde out only one point, but to draw a round, there must be almost infinite points, equidistant from the Centre or middle; that in conclusion it is both the Circle and the Centre together. But contrarily it may seem that to finde the Centre is more difficult, for what attention, vivacitie, and subtiltie must there be in the spirit, in the eye, in the hand, which will chuse the true point amongst a thousand other points? He that makes a circle keeps alwayes the same distance, and is guided by a halfe distance to finish the rest; but he that must finde the Centre, must in the same time take heed to the parts about it, and chooſe one only point which is equall distant from an infinite of other points

points which are in the circumference; which is very difficult. *Aristotle* confirmes this amongst his morals, and seems to explaine the difficultie which is to be found in the middle of vertue; for it may want a thousand wayes, and be farre separated from the true Centre of the end of a right mediocritie of a vertuous action; for to do well it must touch the middle point which is but one, and there must be a true point which respects the end, and that's but one only. Now to judge which is the most difficult, as before is said, either to draw the round or to finde the Centre, the round seems to be harder than to finde the Centre, because that in finding of it, it is done at once, and hath an equall distance from the whole; But, as before, to draw a round there is a visible point imagined, about which the circle is to be drawne. I esteeme that it is as difficult therefore, if not more, to make the circle without a Centre, as to finde the middle or Centre of that circle.

PROBLEM. LVII.

Any one having taken 3 Cards, to finde how many points they containe

THis is to be exercised upon a full Pack of Cards of 52, then let one choose any three at pleasure secretly from your sight, and bid him secretly account the points in each Card, and will him to take as many Cards as will make up 15 to each of the points of his Cards,

then will him to give you the reſt of the Cards, for 4 of them being rejected, thereſt ſhew the number of points that his three Cards which he took at the firſt did conteine. As if the 3 Cards were 7, 10, and 4; now 7 wants of 15, 8. take 8 Cards therefore for your firſt Card: the 10 wants of 15. 5, take 5 cards for your ſecond card: laſtly 4 wants of 15, 11, take 11 Cards for your third Card, & giving him the reſt of the Cards, there will be 25; from which take 4, there remaines 21, the number of the three Cards taken, *viz.* 7, 10, and 4.

Whoſoever would practiſe this play with 4, 5, 6, or more Cards, and that the whole number of Cards be more or leſſe than 52; and that the terme be 15, 14, 12, &c, this generall rule enſuing may ſerve: multiply the terme by the number of Cards taken at firſt: to the product adde the number of Cards taken, then ſubtract this ſumme from the whole number of Cards; the remainder is the number which muſt be ſubtracted from the Cards, which remaines to make up the game: if there remaine nothing after the Subtraction, then the number of Cards remaining doth juſtly ſhew the number of points which were in the Cards choſen. If the Subtraction cannot be made, then ſubtract the number of Cards from that number, and the remainder added unto the Cards that did remaine, the ſumme will be the number of points in the Cards taken, as if the Cards were 7, 10, 5, 8, and the terme given were 12;

ſo

ſo the firſt wants 5, the ſecond wants 2, the third wants 7, and the fourth wants 4 Cards, which taken, the party gives you the reſt of the Cards: then ſecretly multiply 12 by 4, makes 48; to which adde 4, the number of Cards taken makes 52, from which 52 ſhould be taken, reſt nothing: therefore according to the direction of the remainder of the Cards which are 30, is equall to the points of the foure Cards taken, *viz.* 7,10,5,8. Againe, let theſe five Cards be ſuppoſed to be taken, 8,6,10,3,7; their differences to 15, the termes are 7,9,5,12,8, which number of Cards taken, there will remaine but 6 Cards: then privately multiply 15 by 5, makes 75, to which adde 5 makes 80, from this take 52 the number of Cards, reſt 28, to vvhich add the remainder of Cards, make 34. the ſumme with 8, 6,10,3,7.

PROBLEM. LVII.

Many Cards placed in diverſe ranks, to finde which of theſe Cards any one hath thought.

TAke 15 Cards, and place them in 3 heaps in rank-wiſe, 5 in a heap: now ſuppoſe any one had thought one of theſe Cards in any one of the heaps, it is eaſie to finde vvhich of the Cards it is, and it is done thus; ask him in vvhich of the heaps it is, vvhich place in the middle of the other tvvo; then throvv dovvne the Cards by 1 and 1 into three ſeverall heaps in rank-vviſe, untill all be caſt dovvne, then aske him

in which of the rankes his Card is, which heap place in the middle of the other two heaps alwayes, and this do foure times at leaſt, ſo in putting the Cards altogether, look upon the Cards, or let their back be towards you, and throw out the eight Card, for that was the Card thought upon without faile.

PROBLEM. LVIII.

Many Cards being offered to ſundry perſons, to finde which of theſe Cards any one thinketh upon.

ADmit there were 4 perſons, then take 4 Cards, and ſhew them to the firſt, bid him think one of them, and put theſe 4 away, then take 4 other Cards, and ſhew them in like manner to the ſecond perſon, and bid him think any one of theſe Cards, and ſo do to the third perſon, and ſo the fourth, &c. Then take the 4 Cards of the firſt perſon, and diſpoſe them in 4 rankes, and upon them the 4 Cards of the ſecond perſon, upon them alſo theſe of the third perſon, and laſtly, upon them theſe of the fourth perſon, then ſhew unto each of theſe parties each of theſe ranks, and aske him if his Card be in it which he thought; for infallibly that which the firſt partie thought upon will be in the firſt rank, and at the bottome, the Card of the ſecond perſon will be in the ſecond ranke, the

the Card of the third thought upon will be in the third rank, and the fourth mans Card will be in the fourth rank; and ſo of others, if there be more perſons uſe the ſame method. This may be practiſed by other things, ranking them by certaine numbers: allotted to pieces of money, or ſuch like things.

PROBLEME LIX.

How to make an inſtrument to help hearing, as Galileus *made to help the ſight?*

THink not that the Mathematickes (which hath furniſhed us with ſuch admirable helps for ſeeing) is wanting for that of hearing, its well knowne that long trunks or pipes make one heare well farre off, and experience ſhewes us that in certaine places of the *Orcades* in a hollow vault, that a man ſpeaking but ſoftly at one corner thereof, may be audibly underſtood at the other end: notwithſtanding thoſe which are between the parties cannot heare him ſpeak at all: And it is a generall principle, that pipes do greatly help to ſtrengthen the activitie of naturall cauſes: we ſee that fire contracted in a pipe, burnes 4 or 5 foot high, which would ſcarce heat, being in the open aire: the rupture or violence of water iſſuing out of a fountaine, ſhewes us that water being contracted into a pipe, cauſeth a violence in its paſſage. The Glaſſes of *Galeileus* makes us

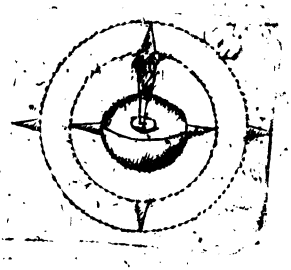
ſee how uſefull pipes or trunkes are to make the light and ſpecies more viſible, and proportionable to our eye. It is ſaid that a Prince of *Italy* hath a faire hall, in which he can with facility heare diſtinctly the diſcourſes of thoſe which walk in the adjacent Gardens, which is by certaine veſſels and pipes that anſwer from the Garden to the Hall. *Vitruvius* makes mention alſo of ſuch veſſels and pipes, to ſtrengthen the voice and action of *Comedians*: and in theſe times amongſt many noble perſonages, the new kinde of trunkes are uſed to help the hearing, being made of ſilver, copper, or other reſounding materiall; in funnell-wiſe putting the wideſt end to him which ſpeaketh, to the end to contract the voice, that ſo by the pipe applied to the eare it may be more uniform and leſſe in danger to diſſipate the voice, and ſo conſequently more fortified.

PROBLEM. LX.

Of a fine lamp which goes not out, though one carry it in ones pocket: or being rolled upon the ground will ſtill burne.

IT muſt be obſerved that the veſſell in which the oile is put into, have two pinnes on the ſides of it, one againſt another, being included within a circle: this circle ought to have two other pinnes, to enter into another circle of braſſe,

braſſe, or other ſolid matter: laſtly, this ſecond circle hath two pinnes, which may hang within ſome box to containe the whole lamp, in ſuch manner, that there be 6 pinnes in different poſition: Now by the aid of theſe pegges or pinnes, the lamp that is in the middle will be alwayes well ſituated according to his Centre of gravity, though it be turned any way: though if you endeavour to turne it upſide downe, it will lie levell: which is pleaſant and admirable to behold to thoſe which know not the cauſe: And it is facil from his to make a place to reſt quiet in, though there be great agitation in the outvvard parts.



PROBLEM. LXI.

Any one having thought a Card amongſt many Cards, how artificially to diſcover it out?

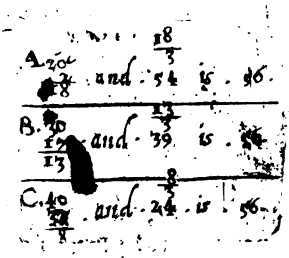
TAke any number of Cards as 10, 12, &c. and open ſome 4 or 5 to the parties ſight, and bid him think one of them, but let him note vvhether it be the firſt, ſecond, third, &c. then vvith promptneſs learn vvhat number of Cards you

you had in your hands, and take the other part of the Cards, and place them on the top of theſe you hold in your hand; and having done ſo, aske him whether his Card were the firſt, ſecond, &c: then before knowing the number of Cards that were at the bottome, account backwards untill you come to it: ſo ſhall you eaſily take out the card that he thought upon.

PROBLEM. LXII.

Three Women A.B.C. carried apples to a marke to ſell, A had 20, B 30, and C 40, they ſold as many for a penny, the one as the other: and brought home one as much money as another, how could this be?

THe anſwer to the Probleme is eaſie, as ſuppoſe at the beginning of the Market: *A.* ſold her apples at a penny an apple: and ſold but 2. which was 2 pence, and ſo ſhe had 18 left: but *B.* ſold 17. which was 17 pence, and ſo had 13 left: *C.* ſold 32. which was 32 pence, and ſo had 8 apples left: then *A* ſaid ſhe would not ſell her apples ſo cheap.



cheap, but would ſell them for 3 pence the peece, which ſhe did: and ſo her apples came to 54 pence, and *B* having left but 13 apples ſold them at the ſame rate, which came to 39 pence: and laſtly, *C.* had but 8 apples, which at the ſame rate came to 24 pence: theſe ſummes of money which each others before received come to 56 pence, and ſo much each one received; and ſo conſequently brought home one as much as another.

PROBLEM. LXIII.

Of the properties of ſome numbers.

FIrſt, any two numbers is juſt the ſumme of a number, that have equall diſtance from the halfe of that number: the one augmenting, and the other diminiſhing, as 7 and 7, of 8 and 6, of 9 and 5, of 10 and 4, of 11 and 3, of 12 and 2, of 13 and 1. as the one is more than the halfe, the other is leſſe.

Secondly, it is difficult to finde two numbers whoſe ſumme and product is alike, (that is) if the numbers be multiplied one by another, and added together, will be equall, which two numbers are 2 and 2, for to multiply 2 by 2 makes 4, and adding 2 unto 2 makes the ſame: this property is in no other two whole numbers, but in broken numbers there are infinite, whoſe ſumme and product will be equall one to another. As *Clavius* ſhewes upon the 36 *Pro.* of the 9th book of *Euclide.*

Thirdly,

Thirdly, the numbers 5 and 6 are called circular numbers, becauſe the circle turnes to the point from whence it begins: ſo theſe numbers multiplied by themſelves, do end alwayes in 5 and 6; as 5 times 5 makes 25, that againe by 5 makes 125, ſo 6 times 6 makes 36, and that by 6 makes 216, &c.

Fourthly, the number 6, is the firſt which Arithmeticians call a perfect number, that is, whoſe parts are equall unto it, ſo the 6 part of it is 1, the third part is 2, the halfe is 3, which are all his parts: now 1, 2, and 3, is equall to 6. It is wonderfull to conceive that there is ſo few of them, and how rare theſe numbers are, ſo of perfect men: for betwixt 1 & 1000000000 numbers there is but ten, that is; 6, 28, 486. 8128. 120816. 2096128. 33550336. 5368544528. 8589869056, & 137438691328: with this admirable property, that alternately they end all in 6 and 8, & the twentieth perfect number is 151115727451555376893 1328.

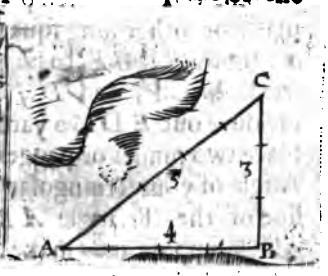
Fiftly, the number 9 amongſt other priviledges carries with it an excellent property: for, take what number you will, either in groſſe or in part, the nines of the whole or in its parts rejected, and taken ſimply will be the ſame, as 27 it makes 3 times 9, ſo whether the nines be rejected of 27, or of the ſumme of 2 and 7, it is all one, ſo if the nines were taken away of 240, it is all one, if the nines were taken away of 2, 4, and 0; for there would remaine 6 in either; and ſo of others.

Sixtly

Sixtly, 11 being multiplied by 2, 4, 5, 6, 7, 8, or 9, will end and begin with like numbers; ſo 11 multiplied by 5 makes 55, if multiplied by 8, it makes 88, *&c.*

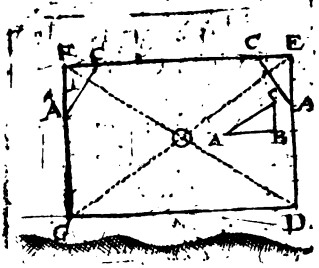
Seventhly, the numbers 220 and 284 being unequall, notwithſtanding the parts of the one number do alwayes equalize the other number: ſo the *aliquot* parts of 220 are 110, 54, 44, 22, 20, 11, 10, 5, 4, 2, 1, which together makes 284. the *aliquot* parts of 284, are 142, 71, 4, 2, 1, which together makes 220, a thing rare and admirable, and difficult to finde in other numbers.

Eightly, the numbers 3, 4, 5, (found out by *Pythagoras*) have an excellent property in making of Rectangle Triangles: upon which the 47 *Pro.* of the firſt book of *Euclide*, was grounded, that the ſquare of the *Hypothenuſal* in any ſuch Triangle, is equal to the ſquare of the other two ſides: that is 5, the *Hypothenuſal* multiplied in 5 makes 25, and 4 multiplied in 4 makes 16, and 3 multiplied in 3, makes 9. but 9 and 16 is equall to 25, or if theſe numbers 3, 4, 5, be doubled, *viz.* 6, 8, 10: the ſquare of 10 is equall to the quare of 8 and 6, *viz.* 10 times 10 makes 100, and 8 times 8 makes 64, and 6 times 6 is 36; which



36 and 64, put together makes 100, as before: and so may they be *Tripled, Quadrupled, &c.*

The use of these numbers 3,4,5, are manifold, but it may be applied thus, for the help of such which plot out Gardens, Houses, encamp Horse or Foot, &c. Example, take 3 cords: one of 5 yards, another of 4 yards, and another of 3 yards, or the double, triple, decuple, &c. or all in one line, and make knots at the tearmes of these measures, so these three parts will make a right angled Triangle, as *A.B.C.* and it is easie with this Triangular cord to plot out a Garden plat, a square building plat, or other long square. As suppose there is a figure *E D G F.* to be plotted, *E D* of 60 yards broad, and *D G* 100 yards long. First measure out *E D* 60 yards, and at *E* and *D* place two pinnes or pegges; then at *E* place the Angle of your Triangular cord *B*, and let the line of the Triangle *A B* be in the line *E D*, which suppose at *A* make the cord *A B* fast in *E* and *A*, then put the other two cords of the Triangle untill they meet, which will be in *C*, and place a pegge at *C*, take afterwards a long cord, and by the points *E* and *C*, augment it unto *F* 100 yards from *E*, and at *F*, place a pegge



pegge; then at *F*, apply your Triangular cord, as you did at *E*, and ſo may you draw the line *F G* as long as *E D*, *viz.* 60 yards. Laſtly, it is eaſie to draw the line *G D*, and ſo the rectangu-led figure or long ſquare ſhall be plotted, whoſe breadth is 60 yards, & length 100 yards, as was required: and to examine this, meaſure *E G*, then if *F D* be as long, the figure is true: other-wiſe it is defective, and may eaſily be amended.

If one be taken from any ſquare number which is odde, the ſquare of halfe of it being added to the firſt ſquare, will make a ſquare number.

The ſquare of halfe any even number + 1 being added to that even number makes a ſquare number, and the even number taken from it leaves a ſquare number.

If odde numbers be continually added from the unitie ſucceſſively, there will be made all ſquare numbers, and if cubick numbers be added ſucceſſively from the unitie, there will be likewiſe made ſquare numbers.

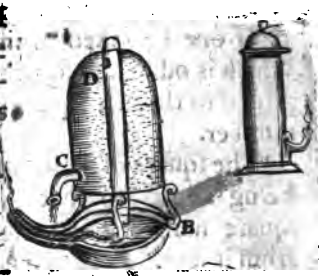
PROBLEM. LXIV.

Of an excellent lamp, which ſerves or furniſheth it ſelfe with oile, and burnes a long time.

I Speak not here of a common lamp which *Cardanus* writes upon in his book *de ſubtilitate*, for that's a little veſſell in columne-wiſe, which

which is full of Oile, and because there is but one little hole at the bottome neare the weeke or match; the oile runnes not, for feare that there be emptineſſe above: when the match is kindled it begins to heat the lamp, and rarefying the oile it iſſueth by this occaſion: and ſo ſends his more airie parts above to avoid vacuitie.

But that which I here deliver, is more ingenious, the principall peece of which is a veſſel, as *C D*. which hath neare the bottome a hole, and a funnell or pipe *C*. & then a bigger funnell, which paſſeth through the middle of the veſſell, having an opening at *D* neare the top, and another at the bottome as at *E*, neer the veſſell under it, ſo that the pipe touch it not: the veſſell being thus made, fill it with oyle, and opening the hole *C*. the oile running out will ſtop the hole at *E*, or throwing in oile into the veſſell underneath, untill *E* be ſtopped, then the oile at *C* will not runne: becauſe no aire can come into the pipe *D E*. Now as the oile burneth and conſumeth in the veſſell *A B*, the hole at *E*, will begin to be open, then immediately will *C* begin to runne to fill up *A B*. and *E* being ſtopped with the oile, the oile at *C* ceaſeth to run.



It

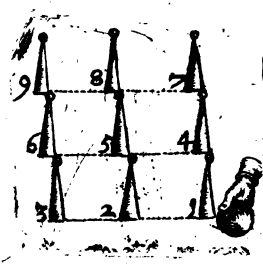
It is certaine that ſuch a lampe the *Athenians* uſed, which laſted a whole yeare without being touched: which was placed before the ſtatue of *Minerva*, for they might put a certaine quantitie of oile in the lamp *C D*, and a match to burne without being conſumed: ſuch as the naturaliſts write of, by which the lamp will furniſh it ſelfe, and ſo continue in burning: and here may be noted that the oile may be poured in, at the top of the veſſell at a little hole, and then made faſt againe, that the aire get not in.

PROBLEM. LXV.

Of the play at Keyles or nine Pinnes.

YOu will ſcarce beleeve that with one bowle and at one blow playing freely, one may ſtrike downe all the Keyles at once: yet from Mathematicall principles it is eaſie to be demonſtrated, that if the hand of him that playes were ſo well aſſured by experience, as reaſon induceth one thereto; one might at one blow ſtrike downe all the Keyles, or at leaſt 7 or 8, or ſuch a number as one pleaſeth.

For they are but 9 in all diſpoſed or placed in a perfect ſquare, having three every way. Let us ſuppoſe then that a good player beginning to play at 1 ſomewhat low, ſhould ſo ſtrike it, that it ſhould ſtrike downe the Keyles 2 and 5, and theſe might in their violence ſtrike



downe the Keyles 3, 6, and 9, and the bowle being in motion may ſtrike down the Keyle 4, and 7; which 4 Keyle may ſtrike the Keyle 8, & ſo all the 9 Keyles may be ſtriken down at once.

PROBLEM. LXIV.

Of Spectacles of pleaſure.

SImple Spectacles of blew, yellow, red or green colour, are proper to recreate the ſight, and will preſent the objects died in like colour that the Glaſſes are, only thoſe of the greene do ſomewhat degenerate; inſtead of ſhewing a lively colour it will repreſent a pale dead colour, and it is becauſe they are not dyed greene enough, or receive not light enough for greene: and colour theſe images that paſſe through theſe Glaſſes unto the bottome of the eye.

EXAMINATION.

IT is certaine, that not onely Glaſſes dyed greene, but all other Glaſſes coloured, yield the appearances of objects ſtrong or weak in colour according to the quantity of the dye, more or leſſe, as one being very yellow, another

another a pale yellow; now all colours are not proper to Glasses to give colour, hence the defect is not that they want faculties to receive light, or resist the penetration of the beams; for in the same Glasses those which are most dyed, give always the objects more high coloured and obscure, and those which are lesse dyed give them more pale and cleare: and this is daily made manifest by the painting of Glasse, which hinders more the penetration of the light than dying doth, where all the matter by fire is forced into the Glasse; leaving it in all parts transparent.

Spectacles of Crystall cut with divers Angles diamond-wise do make a marvellous multiplication of the appearances, for looking towards a house it becomes as a Towne, a Towne becomes like a Citie, an armed man seems as a whole company caused solely by the diversity of refractions, for as many plaines as there are on the outside of the spectacle, so many times will the object be multiplied in the appearance, because of diverse Images cast into the eye. These are pleasurable spectacles for avaricious persons that love Gold and silver, for one piece will seeme many, or one heap of money will seeme as a treasury: but all the mischiefe is, he will not have his end in the enjoying of it, for indeavouring to take

it, it will appeare but a deceitfull Image, or delusion of nothing. Here may you note that if the finger be directed by one and the same ray or beam, which pointeth to one and the same object, then at the first you may touch that visible object without being deceived: otherwise you may faile often in touching that which you see. Againe, there are Spectacles made which do diminish the thing seen very much, and bring it to a faire perspective forme, especially if one look upon a faire Garden plat, a greater walk, a stately building, or great Court, the industry of an exquisite Painter cannot come neare to expresse the lively forme of it as this Glasse will represent it; you will have pleasure to see it really experimented, and the cause of this is, that the Glasses of these Spectacles are hollow and thinner in the middle, than at the edges by which the visuall Angle is made lesser: you may observe a further secret in these Spectacles, for in placing them upon a window one may see those that passe to and fro in the streets, without being seen of any, for their property is to raise up the objects that it looketh upon.

Now I would not passe this Probleme without saying something of Galileus *admirable Glasse, for the common simple perspective Glasses give to ordinary men but the eyes or sight of young men, but this of* Galileus *gives a man an Eagles eye, or an eye that pierceth the heavens: first it discovereth the spottie and shadowed opacous bodies that are found about the Sunne, which darkneth and diminisheth the splendor of that beautifull and shining Luminary: secondly, it shewes the new Planets that accompany*

company Saturne and Jupiter: thirdly, in Venus is seen the new, full, and quartill increase; as in the Moon by her separation from the Sunne: fourthly, the artificiall structure of this instrument helpeth us to see an innumerable number of stars, which otherwise are obscured, by reason of the naturall weaknesse of our sight, yea the starres in via lactea are seen most apparantly, where there seem no starres to be, this Instrument makes apparantly to be seen, and further delivers them to the eye in their true and lively colour, as they are in the heavens: in which the splendor of some is as the Sunne in his most glorious beauty. This Glasse hath also a most excellent use in observing the body of the Moone in time of Eclipses, for it augments it manifold, and most manifestly shewes the true forme of the cloudy substance in the Sunne; and by it is seene when the shadow of the earth begins to eclipse the Moon, & when totally she is over shadowed: besides the celestiall uses which are made of this Glasse, it hath another noble property; it farre exceedeth the ordinary perspective Glasses, which are used to see things remote upon the earth, for as this Glasse reacheth up to the heavens and excelleth them therein his performance, soon the earth it claimeth

preheminency, for the objects which are farthest remote, and most obscure, are seen plainer than those which are neere at hand, scorning as it were all small and triviall services, as leaving them to an inferiour help: great use may be made of this Glass in discovering of Ships, *Armies, &c. Now the apparell or parts of this instrument or Glasse, is very meane or simple, which makes it the more admirable (seeing it performes such great service) having but a convex Glasse thickest in the middle, to unite and amasse the rayes, and mak the object the greater: to the augmenting the visuall Angle, as also a pipe or trunk to amasse the* Species, *and hinder the greatness of the light which is about it:* (to see well, the object must be well inlightened, and the eye in obscurity,) *then there is adjoyned unto it a Glasse of a short sight to distinguish the rayes, which the other would make more confused if alone. As for the proportion of those Glasses to the Trunk, though there be certaine rules to make them, yet it is often by hazard that there is made an excellent one there being so many difficulties in the action, therefore many ought to be tryed, seeing that exact proportion, in Geometricall calculation cannot serve for diversity of sights in the observation.*

Prop.

PROBLEM. LXVII.

Of the Adamant or Magnes, and the needles touched therewith.

WHo would beleeve if he ſaw not with his eyes, that a needle of ſteel being once touched with the *magnes*, turnes not once, not a yeare, but as long as the World laſteth; his end towards the North and South, yea though one remove it, and turne it from his poſition, it will come againe to his points of North and South. Who would have ever thought that a brute ſtone black and ill formed, touching a ring of Iron, ſhould hang it in the aire, and that ring ſupport a ſecond, that to ſupport a third, and ſo unto 10, 12, or more, according to the ſtrength of the *magnes*; making as it were a chaine without a line, without ſouldering together, or without any other thing to ſupport them onely; but a moſt occult and hidden vertue, yet moſt evident in this effect, which penetrateth inſenſibly from the firſt to the ſecond, from the ſecond to the third, &c.

Is it not a wonder to ſee that a needle touched once will draw other needles; and ſo a naile, the point of a knife, or other pieces of Iron? Is it not a pleaſure to ſee how the *magnes* will turne file duſt, or move needles, or nailes being upon a Table, or upon a piece of paper? for as ſoone as the *magnes* turnes or moves over, it moves alſo; who is it that would not be ra-

viſhed as it were, to ſee a hand of Iron write upon a plánke, without ſeeing the *Magnes* which cauſeth that motion behinde the plánke, or to make an image of Iron to run up and downe a Turret: now infinite of ſuch inventions is proper to be extracted from the properties of the *magnes*.

What is there in the world that is more capable to caſt a deeper aſtoniſhment in our minds than a great maſſie ſubſtance of Iron to hang in the aire in the middeſt of a building without any thing in the world touching it, only but the aire? As ſome hiſtories aſſure us, that by the aid of a *Magnes* or Adamant, placed at the roof of one of the Turkiſh Synagogues in *Mecca*: the ſepulchre of that infamous *Mahomet* reſts ſuſpended in the aire; and *Plinie* in his naturall Hiſtorie writes that the Architector *Democrates* did begin to vault the Temple of *Arſinoe* in *Alexandria*, with ſtore of *magnes* to produce the like deceit, to hang the ſepulchre of that Goddeſſe likewiſe in the aire.

I ſhould paſſe the bounds of my counterpoiſe, if I ſhould divulge all the ſecrets of this ſtone,

ſtone, and ſhould expoſe my ſelfe to the laughter of the world: if I ſhould brag to ſhew others the cauſe how this appeareth, than in its owne naturall ſympathy, for why is it that a *magnes* with one end will caſt the Iron away, & attract it with the other? from whence commeth it that all the *magnes* is not proper to give a true touch to the needle, but only in the two Poles of the ſtone: which is known by hanging the ſtone by a threed in the aire untill it be quiet, or placed upon a peece of Cork in a diſh of water, or upon ſome thinne board, for the Pole of the ſtone will then turne towards the Poles of the world, and point out the North and South, and ſo ſhew by which of theſe ends the needle is to be touched?

From whence comes it that there is a variation in the needle, and pointeth not out truly the North and South of the world, but only in ſome place of the earth?

How is it that the needle made with pegges and incloſed within two Glaſſes, ſheweth the height of the Pole, being elevated as many degrees as the Pole is above the Horizon?

What's the cauſe that fire and Garlick takes away the propertie of the *magnes*? There are many great hidden myſteries in this ſtone, which have troubled the heads of the moſt learned in all ages, and to this time the world remaines ignorant of declaring the true cauſe thereof.

Some ſay, that by help of the *Magnes* perſons which are abſent may know each others minde,

minde, as if one being here at *London*, and another at *Prague* in *Germany*: if each of them had a needle touched with one *magnes*, then the vertue is such that in the same time that the needle which is at *Prague* shall move, this that is at *London* shall also; provided that the parties have like secret notes or alphabets, and the observation be at a set houre of the day or night; and when the one party will declare unto the other, then let that party move the needle to these letters which will declare the matter to the other, and the moving of the other parties needle shall open his intention.

The invention is subtile, but I doubt whether in the world there can be found so great a stone, or such a *Magnes* which carries with it such vertue: neither is it expedient, for treasons would be then too frequent and open.

EXAMINATION.

THe experimentall difference of rejection, and attraction proceeds not from the different nature of Stones, but from the quality of the Iron, and the vertue of the stone consisteth only, and especially in his poles, which being hanged in the Aire, turnes one of his ends alwayes naturally towards the South, and the other towards the North: but if a rod of Iron be touched with one of the ends thereof, it hath the like property in

turning

turning North and South, as the magnes hath: notwithstanding the end of the Iron Rod touched, hath a contrary position, to that end of the stone that touched it; yet the same end will attract it, and the other end reject it: and so contrarily this may easily be experimented upon two needles touched with one or different stones, though they have one and the same position; for as you come unto them apply one end of the magnes neare unto them, the North of the one will abhorre the North of the other, but the North of the one will alwayes approach to the South of the other: and the same affection is in the stones themselves. For the finding of the Poles of the magnes, it may be done by holding a small needle between your fingers softly, and so moving it from part to part over the stone untill it be held perpendicular, for that shall be one of the Poles of the stone which you may marke out, in like manner finde out the other Pole: Now to finde out which of those Poles is North or South, place a needle being touched with one of the Poles upon a smooth convex body, (as the naile of ones finger or such like,) and marke which way the end of the needle that was touched turneth: if to the South, then the point that

touched

touched it was the South-Pole, &c. and it is moſt certain and according to reaſon and experience: that if it be ſuſpended in aquilibrio in the aire, or ſupported upon the water, it will turne contrary to the needle that toucheth it; for then the pole that was marked for the South ſhall turne to the North, &c.

Problem. LXVIII.

Of the properties of Æolipiles or bowels to blow the fire.

THeſe are concave veſſels of Braſs or Copper or other material, which may indure the fire: having a ſmall hole very narrow, by which it is filled with water, then placing it to the fire, before it be hot there is no effect ſeen; but aſſoone as the heat doth penetrate it, the water begins to rarefie, & iſſueth forth with a hidious and marvelous force; it is pleaſure to ſee how it blowes the fire with great noiſe.

Vitruvius in his firſt book of *Architecture*, *Cap.* 8. approves from theſe Engines, that winde is no other thing than a quantity of vapours and exhalations agitated with the aire by rarefaction and condenſation, and we may draw a conſequence from it, to ſhew that a little water.

ter may ingender a very great quantitie of vapours and aire: for a Glasse of water throwne into an *Æolipile* will keep blowing neare a vvhole houre, sending forth his vapours a thousand times greater than it is extended.

Novv touching the forme of these vessels, they are not made of one like fashion: some makes them like a bovvle, some like a head painted representing the vvinde, some make them like a Peare: as though one vvould put it to rost at the fire, vvhen one vvould have it to blovv, for the taile of it is hollovv, in forme of a funnell, having at the top a very little hole no greater than the head of a pine.

Some do accustome to put vvithin the *Æolipile* a crooked funnell of many foldings, to the end that the vvinde that impetuously tolles, to and fro vvithin, may imitate the noise of thunder. Others content themselves vvith a simple funnell placed right upvvard, somevvhat vvider at the top than elsevvhere like a Cone, vvhose basis is the mouth of the funnell: and there may be placed a bovvle of Iron or Brasse, vvhich by the vapours that are cast out vvithin cause it to leap up, and dance over the mouth of the *Æolipile*.

Lastly, some apply neer to the hole smal Windmils, or such like, vvhich easily turne by reason of the vapours; or by help of two or more bovved funnels, a bowle may be made to turne: these *Æolipiles* are of excellent use for the melting of mettalls and such like.

Novv

Now it is cunning and subtiltie to fill one of these *Æolipiles* with water at so little a hole, and therefore requires the knowledge of a Philosopher to finde it out: and the way is thus.

Heat the *Æolipiles* being empty, and the aire which is within it will become extreamely rarefied; then being thus hot throw it into water, and the aire will begin to be condensed: by which meanes it will occupie lesse roome, therefore the water will immediately enter in at the hole to avoide vacuitie: thus you have some practicall speculation upon the *Æolipile*.

PROBLEM. LXIX.

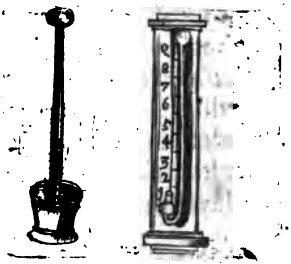
Of the Thermometer: or an instrument to measure the degrees of heat and cold in the aire.

THis Instrument is like a *Cylindricall* pipe of Glasse, which hath a little ball or bowle at the toppe: the small end of which is placed into a vessell of water below, as by the figure may be seene.

Then put some coloured liquor into the Cylindricall glasse, as blew, red, yellow, green, or such like: such as is not thick. This being done the use may be thus.

First, I say, that as the aire inclosed in the *Thermometer* is rarefied or condensed, the water will evidently ascend or descend in the Cylinder: which you may try easily by carrying the *Thermometer* from a place that is hot unto a place that is cold, or without removing of it; if you softly apply the palme of the hand upon the ball

ball of the *Thermometer*: the Glaſſe being ſo thinne, and the aire ſo capable of rarefaction, that at the very inſtant you may ſee the water deſcend: and your hand being taken away, it will ſoftly aſcend to his formes place againe. This is yet more ſenſible when one heats the ball at the top with his breath, as if one would ſay a word in his eare to make the water to deſcend by command, and the reaſon of this motion is, that the aire heated in the *Thermometer*, doth rarefie and dilate, requiring a greater place; hence preſſeth the water and cauſeth it to deſcend: contrariwiſe when the aire cooleth and condenſeth, it occupieth leſſe roome; now nature abhorring vacuity, the water naturally aſcendeth. In the ſecond place, I ſay, that by this meanes one may know the degrees of heat and cold, which are in the aire each houre of the day; foraſmuch as the exterior aire is either hot or cold, the aire which is incloſed in the *Thermometer* doth likewiſe either rarefie or condenſe, and therefore the water aſcends or deſcends; ſo you ſhall ſee that the water in the morning is mounted high, afterward by little and little it will deſcend towards noone or mid-day; and towards evening it will againe aſcend: ſo in winter it will mount ſo high, that all the Cylinder of the *Thermometer* will be full, but



in

in Summer, it will deſcend ſo low that ſcarce there will be percea ved in it any water at all.

Thoſe that will determine this change by numbers and degrees, may draw a line upon the Cylinder of the *Thermometer*; and divide it into 4 degrees, according to the ancient *Philoſophers*, or into 4 degrees according to the Phyſicians, dividing each of theſe 8 into 8 others: to have in all 64 diviſions, & by this vvay they may not only diſtinguiſh upon vvhat degree the vvater aſcendeth in the morning, at midday, & at any other houre: but alſo one may knovv hovv much one day is hotter or colder than another: by marking hovv many degrees the vvater aſcendeth or deſcendeth, one may compare the hotteſt and coldeſt dayes in a vvhole year together vvith theſe of another year: againe one may knovv hovv much hotter one roome is than another; by vvhich alſo one might keep a chamber, a furnace, a ſtove, &c. alvvayes in an equalitie of heat, by making the vvater of the *Thermometer* reſt alvvayes upon one & the ſame degree: in briefe, one may judge in ſome meaſure the burning of Fevers, and neare unto, what extenſion the aire canbe rarefied by the greateſt heat.

Many make uſe of theſe glaſſes to judge of the vveather: for it is obſerved that if the vvater fall in 3 or 4 hours a degree or thereabout, that raine inſueth; and the vvater vvill ſtand at that ſtay, untill the vveather change: marke the water at your going to bed, for if in the morning it hath deſcended raine followeth, but if it be

mounted

mounted higher, it argueth faire weather: ſo in very cold weather, if it fall ſuddenly, it is ſnow or ſome fleekey weather that will inſue.

Problem. LXX.

Of the proportion of humane bodies of ſtatues, of Coloſſus or huge images, and of monſtrous Giants.

Pythagoras had reaſon to ſay that man is the meaſure of all things.

Firſt, becauſe he is the moſt perfect amongſt all bodily creatures, & according to the *Maxime* of Philoſophers, that which is moſt perfect and the firſt in rank, meaſureth all the reſt.

Secondly, becauſe in effect the ordinary meaſure of a foot, the inch, the cubit, the pace, have taken their names and greatneſſe from humane bodies.

Thirdly, becauſe the *ſymmetrie* and concordancie of the parts is ſo admirable, that all workes which are well proportionable, as namely the building of Temples, of Shippes, of Pillars, and ſuch like pieces of Architecture, are in ſome meaſure faſhioned and compoſed after his proportion. And we know that the Arke of *Noah* built by the commandement of God, was in length 300 Cubits, in breadth 50 Cubits, in height or depth 30 cubits, ſo that the length containes the breadth 6 times, and 10 times the depth: now a man being meaſured

you will finde him to have the ſame proportion in length, breadth, and depth.

Vilalpandus treating of the Temple of *Solomon* (that chieftaine of works) was modulated all of good *Architecture*, and curiouſly to be obſerved in many pieces to keep the ſame proportion as the body to his parts: ſo that by the greatneſſe of the work and proportionable *ſymmetrie*, ſome dare aſſure themſelves that by knowledge of one onely part of that building, one might know all the meaſures of that goodly ſtructure.

Some *Architects* ſay that the foundation of houſes, and baſis of columnes, are as the foot; the top, and roofe as the head; the reſt as the body: thoſe which have beene ſomewhat more curious, have noted that as in humane bodies, the parts are uniforme, as the noſe, the mouth, &c. theſe which are double are put on one ſide or other, with a perfect equality in the ſame *Architecture*.

In like manner, ſome have been yet more curious than ſolid; comparing all the ornaments of a *Corinth* to the parts of the face, as the brow, the eyes, the noſe, the mouth; the rounding of Pillars, to the vvrithing of haire, the channells of columnes, to the fouldings of vvomens Robes, &c.

Novv building being a vvork of the beſt *Artiſt*, there is much reaſon vvhy man ought to make his imitation from the chiefe vvork of nature; vvhich is man.

Hence it is that *Vitruvius* in his third book, and

and all the beſt *Architectes*, treate of the proportion of man; amongſt others *Albert Durers* hath made a whole book of the meaſures of mans body, from the foot to the head, let them read it who wil, they may have a prefect knowledge thereof: But I will content my ſelfe and it may ſatisfie ſome with that which followeth.

Firſt, the length of a man well made, which commonly is called height, is equall to the diſtance from one end of his finger to the other: when the armes are extended as wide as they may be.

Secondly, if a man have his feet and hands extended or ſtretched in forme of S: *Andrews* Croſſe, placing one foot of a paire of Compaſſes upon his navill, one may deſcribe a circle which will paſſe by the ends of his hands and feet, and drawing lines by the termes of the hands and feet, you have a ſquare within a circle.

Thirdly, the breadth of man, or the ſpace which is from one ſide to another; the breaſt, the head, and the neck, make the 6 part of all the body taken in length or height.

Fourthly, the length of the face is equall to the length of the hand, taken from the ſmall of the arme, unto the extremity of the longeſt finger.

Fiftly, the thickneſſe of the body taken from the belly to the back; the one or the other is the tenth part of the whole body, or as ſome will have it, the ninth part, little leſſe.

Sixtly, the height of the brow, the length of

the noſe, the ſpace between the noſe and the chinne, the length of the eares, the greatneſſe of the thumbe, are perfectly equall one to the other.

What would you ſay to make an admirable report of the other parts, if I ſhould reckon them in their leaſt? but in that I deſire to be excuſed, and will rather extract ſome concluſion upon that which is delivered.

In the firſt place, knowing the proportion of a man, it is eaſie to Painters, Image-makers, &c. perfectly to proportionate their work; and by the ſame is made moſt evident, that which is related of the images and ſtatues of Greece, that upon a day diverſe workmen having enterpriſed to make the face of a man, being ſevered one from another in ſundry places, all the parts being made and put together, the face was found in a moſt lively and true proportion.

Secondly, it is a thing moſt cleare, that by the help of proportion, the body of *Hercules* was meaſured by the knowledge of his foot onely, a Lion by his claw, the Giant by his thumb, and a man by any part of his body. For ſo it was that *Pythagoras* having meaſured the length of *Hercules* foot, by the ſteps which were left upon the ground, found out all his height: and ſo it was that *Phidias* having oneiy the claw of a Lion, did figure and draw out all the beaſt according to his true type or forme, ſo the exquiſite Painter *Timantes*, having painted a *Pygmey* or Dwarfe, which he meaſured with a fadome made with the inch of a Giant, it was ſufficient

ent

ent to know the greatneſſe of that Giant.

To be ſhort, we may by like methode come eaſily to the knowledge of many fine antiquities touching Statues, Coloſſus, and monſtrous Giants, onely ſuppoſing one had found but one only part of them, as the head, the hand, the foot or ſome bone mentioned in ancient Hiſtories.

Of Statues, of Coloſſus, or huge images.

Vitruvius relates in his ſecond book, that the *Architect Dinocrates* was deſirous to put out to the world ſome notable thing, went to *Alexander* the great, and propoſed unto him a high and ſpeciall piece of work which he had projected: as to figure out the mount *Athos* in forme of a great Statue, which ſhould hold in his right hand a Towne capable to receive ten thouſand men: and in his left hand a veſſell to receive all the water that floweth from the Mountaine, which with an ingine ſhould caſt into the Sea This is a pretty project, ſaid *Alexander*, but becauſe there was not field-roome thereabout to nouriſh and reteine the Citizens of that place, *Alexander* was wiſe not to entertaine the deſigne.

Now let it be required of what greatneſſe this Statue might have been, the Towne in his right hand, and the receiver of water in his left hand if it had been made.

For the Statue it could not be higher than the Mountaine it ſelfe, and the Mountaine was about a mile in height plumb or perpendicular;

therefore the hand of this Statue ought to be the 10th part of his height, which would be 500 foot, and so the breadth of his hand would be 250 foot, the length now multiplyed by the breadth, makes an hundred twenty five thousand square feet, for the quantitie of his hand to make the towne in, to lodge the said 10 thousand men, allowing to each man neere about 12 foot of square ground: now judge the capacitie of the other parts of this *Colloſſus* by that which is already delivered.

Secondly, *Plinie* in his 34 book of his natural Hiſtory, ſpeakes of the famous *Coloſſus* that was at *Rhodes*, between whoſe legges a Shippe might paſſe with his ſailes open or diſplayed, the Statue being of 70 cubits high: and other Hiſtories report that the *Saraſens* having broken it, did load 900 Camels with the mettal of it, now what might be the greatneſſe and weight of this Statue?

For anſwer, it is uſually allowed for a Camels burthen 1200 pound weight, therefore all the *Colloſſus* did weigh 1080000 pound weight, which is ten hundred and fourſcore thouſand pound vveight.

Novv according to the former rules, the head being the tenth part of the body, this Statues head ſhould be of 7 cubits, that is to ſay, 10 foot and a halfe, and ſeeing that the Noſe, the brovv, and the thumbe, are the third part of the face, his Noſe vvas a foot and a halfe long, and ſo much alſo vvas his thumbe in length: now the thickneſſe being alvvayes the third part of the

the length, it ſhould ſeem that his thumb was a foot thick at the leaſt.

Thirdly, the ſaid *Plinie* in the ſame place reports that *Nero* did cauſe to come out of *France* into *Italy*, a brave and bold Statue-maker called *Zenodotus*, to erect him a *Coloſſus* of braſſe, which was made of 120 foot in height, which *Nero* cauſed to be painted in the ſame height. Now would you know the greatneſſe of the members of this *Coloſſus*, the breadth would be 20 foot, his face 12 foote, his thumb and his noſe 4 foot, according to the proportion before delivered.

Thus I have a faire field or ſubject to extend my ſelfe upon, but it is upon another occaſion that it was undertaken, let us ſpeak therefore a word touching the Giants, and then paſſe away to the matter.

Of monſtrous Giants.

YOu will hardly beleeve all that which I ſay touching this, neither will I beleeve all that which Authors ſay upon this ſubject: notwithſtanding you nor I cannot deny but that long ago there have been men of a moſt prodigious greatneſſe; for the holy vvritings vvitneſſe this themſelves in *Deut, Chap.* 3. that there vvas a certaine Giant called *Og*, of the Town of *Rabath*, vvho had a bed of Iron, the length thereof vvas 9 cubits, and in breadth 4 cubits.

So in the firſt of *Kings Chap.* 17. there is mention made of *Goliah*, vvhoſe height vvas a

palme and 6 cubits, that is more then 9 foot, he was armed from the head to the foot, and his Curiat onely with the iron of his lance, weighed five thousand and six hundred shekels, which in our common weight, is more than 233 pound, of 12 ounces to the pound: Now it is certaine, that the rest of his armes taking his Target, Helmet, Brocelets, and other Armour together, did weigh at the least 5 hundred pound, a thing prodigious; seeing that the strongest man that now is, can hardly beare 200 pound, yet this Giant carries this as a vesture without paine.

Solinus reporteth in his 5 *Chap.* of his Historie, that during the Grecians warre after a great overflowing of the Rivers, there was found upon the sands the carcase of a man, whose length was 33 Cubits, (that is 49 foot and a halfe) therefore according to the proportion delivered, his face should be 5 foot in length, a thing prodigious and monstrous.

Plinie in his 7. book and 16 *Chap.* saith, that in the Isle of *Creta* or *Candia*, a mountaine being cloven by an Earth-quake; there was a body standing upright, which had 46 Cubits of height: some beleeve that it was the body of *Orion*, or *Othus*, (but I think rather it was some Ghost or some delusion) whose hand should have beene 7 foot, and his nose two foot and a half long. But that which *Plutarch* in the life of *Sertories* reports of, is more strange, who saith, that in *Tingy* a Morative Towne, where

it

it is thought that the Giant *Antheus* was buried, *Sertorius* could not beleeve that which was reported of his prodigious greatneſſe, cauſed his ſepulchre to be opened, and found that his body did containe 60 Cubits in length, then by proportion he ſhould be 10 Cubits or 15 foot in breadth, 9 foot for the length of his face, 3 foot for his thumb, which is neare the capacitie of the *Coloſſus* at *Rhodes*.

But behold here a fine fable of *Symphoris Campeſius*, in his book intituled *Hortus Gallicus*, who ſayes that in the Kingdome of *Sicilie*, at the foot of a mountaine neare *Trepane*, in opening the foundation of a houſe, they found a Cave in which was laid a Giant, which held in ſtead of a ſtaffe a great poſt like the maſt of a Ship: and going to handle it, it mouldered all into aſhes, except the bones which remained of an exceeding great meaſure, that in his head there might be eaſily placed 3 quarters of corn, and by proportion it ſhould ſeeme that his length was 200 cubits, or 300 foot: if he had ſaid that he had been 300 cubits in length, then he might have made us beleeve that *Noahs* Ark was but great enough for his ſepulchre.

Who can believe that any man ever had 20 cubits, or 30 foot in length for his face, and a noſe of 10 foot long? but it is very certaine that there have been men of very great ſtature, as the holy Scriptures before witneſſe, and many Authours worthy of beliefe relate: *Joſephus Acoſta* in his firſt book of the Indian Hiſtory, *Chap.* 19. a late writer, reporteth, that

at

at *Peru* was found the bones of a Giant, which was 3 times greater than theſe of ours are, that is 18 foot, for it is uſually attributed to the talleſt ordinary man in theſe our times but 6 foot of length; and Hiſtories are full of the deſcription of other Giants of 9, 10, and 12 foot of height, and it hath been ſeen in our times ſome which have had ſuch heights as theſe.

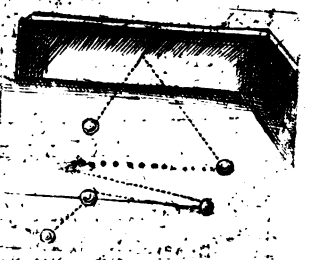
PROBLEM. LXXI.

Of the game at the Palme, at Trap, at Bowles, Paile-maile, and others.

THe Mathematicks often findeth place in ſundry Games to aid and aſſiſt the Gameſters, though not unknowne unto them, hence by Mathematicall principles, the games at Tennis may be aſſiſted, for all the moving in it is by right lines and reflections. From whence comes it, that from the appearances of flat or convex Glaſſes; the production and reflection of the ſpecies are explained; is it not by right lines? in the ſame proportion one might ſufficiently deliver the motion of a Ball or Bowle by Geometrical lines and angles.

But the exerciſe, experience, and dexteritie of the player ſeems more in this action, than any other precepts: notwithſtanding I will deliver here ſome *maximes*, which being reduced to practice, and joyned to experience, will give

give a great advantage to those which would make use of them in such gamings.



And the first maxime is thus: When a Bowle toucheth another Bowle, or when a trapstick striketh the Ball, the moving of the Ball is made in a right line, which is drawne from the Centre of the Bowle by the point of contingencie.

Secondly, in all kinde of such motion; when a Ball or Bowle rebounds, be it either against wood, a wall, upon a Drumme, a pavement, or upon a Racket; the incident Angle is alwayes equall to the Angle of reflection.

Now following these *maximes*, it is easie to conclude, first, in what part of the wood or wall, one may make the Bowle or Ball go to reflect or rebound, to such a place as one would. Secondly, how one may cast a Bowle upon another, in such sort that the first or the second shall go and meet with the third, keeping the reflection or Angle of incidence equal.

Thirdly, how one may touch a Bowle to send it to what part one pleaseth; such and many other practices may be done. At the exercises at Keyls there must be taken heed that the motion slack or diminish by little and little, and

may

may be noted that the *Maximes* of reflections cannot be exactly observed by locall motion, as in the beames of light and of other qualities, whereof it is necessary to supply it by industry or by strength, otherwise one may be frustrated in that respect.

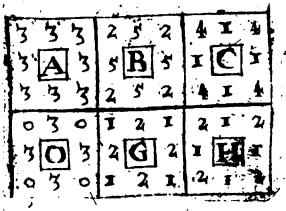
PROBLEM LXXII.

Of the Game of square formes.

NVmbers have an admirable secrecie, diversly applied, as before in part is shewed, and here I will say something by way of transmutation of numbers.

It is reported that at a certaine passage of a square forme, there were 4 gates opposite one to another; that is, one in the middle of each side, and that there were appointed 9 men to defend each front thereof, some at the gates, & the other at each corner or Angle, so that each Angle served to assist two faces of the square, if need required: Now this square passage being thus manned to have each side 9, it happened that 4 Souldiers comming by, desired of the Governour of the passage, that they might be entertained into service, who told them he could not admit of more then 9, upon each side of the square: then one of the Souldiers being versed in the Art of numbers, said, that if he would take them into pay, they would easily place themselves amongst the rest, and yet keep

keep ſtill the order of 9, for each face of the ſquare to defend the Angles & Gates, to which the Governours agreed, and theſe Souldiers being there ſome few weeks liked not their ſervice



but indeavoured to remove themſelves, and ſo laboured with ſome of the the reſt; that each of theſe foure Souldiers took away his cumrade with him, and ſo departed; yet left to defend each ſide of the paſſage, and how may this be?

It's anſwered thus, in the firſt forme the men were as the figure *A*, then each of theſe 4 Souldiers placed themſelves at each Gate, and removing one man from each Angle to each Gate, then would they be alſo 9 in each ſide according to the figure *B*. Laſtly, theſe 4 Souldiers at the Gates take away each one his Cumrade, and placing two of theſe men which are at each Gate to each Angle, there will be ſtill 9 for each ſide of the ſquare, according to the figure *C*. In like manner if there were 12 men, how might they be placed about a ſquare that the firſt ſide ſhall have 3 every way, then diſordered, ſo that they might be 4 every way; and laſtly, being tranſported might make 5 every way? & this is according to the figures, *F.G.H*

PROBLEM. LXXIII.

How to make the ſtring of a Viole ſenſibly ſhake; without any one touching it?

THis is a miracle in muſick, yet eaſie to be experimented. Take a Viole or other Inſtrument, and chooſe two ſtrings, ſo that there be one between them; make theſe two ſtrings, agree in one and the ſame tune: then move the Viole-bowe upon the greater ſtring; and you ſhall ſee a wonder: for in the ſame time that that ſhakes which you play upon, the other will likewiſe ſenſibly ſhake without any one touching it; and it is more admirable that the ſtring which is between them will not ſhake at all: and if you put the firſt ſtring to another tune or note, and looſing the pin of the ſtring, or ſtopping it with your finger in any fret, the other ſtring will not ſhake: and the ſame will happen if you take two Violes, and ſtrike upon a ſtring of the one, the ſtring of the other will ſenſibly ſhake.

Now it may be demanded, how comes this ſhaking, is it in the occult ſympathie, or is it in the ſtrings being wound up to like notes or tunes, that ſo eaſily the other may receive the impreſſion of the aire, which is agitated or moved by the ſhaking or the trembling of the other? & whence is it that the Viole-bowe moved upon the firſt ſtring, doth inſtantly in the ſame time move the third ſtring, and not the ſecond? if the cauſe be not either in the firſt or ſecond? I leave to others to deſcanton.

EX-

EXAMINATION.

IN this Examination we have ſomething elſe to imagine, than the bare ſympathie of the Cords one to another: for firſt there ought to be conſidered the different effect that it produceth by extention upon one and the ſame Cord in capacitie: then what might be produced upon different Cords of length and bigneſs to make them accord in a uniſone or octave, or ſome conſort intermediate: this being naturally examined, it will be facill to lay open a way to the knowledge of the true and immediate cauſe of this noble and admirable Phænomeny. *Now this will ſenſibly appeare when the Cords are of equall length and greatneſſe, and ſet to an uniſone; but when the Cords differ from their equalitie, it will be leſſe ſenſible: hence in one and the ſame Inſtrument, Cords at a uniſone ſhall excite or ſhake more than that which is at an octave, and more than thoſe which are of an intermediate proportionall conſort: as for the other conſorts they are not exempted, though the effect be not ſo ſenſible, yet more in one than in another: and the experiment will ſeem more admirable in taking 2 Lutes, Viols, &c. & in ſetting them to one tune: for then in touching the Cord of the one, it will*

give

give a ſenſible motion to the Cord of the o-ther: and not onely ſo but alſo a harmony.

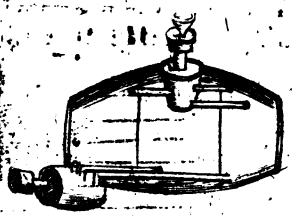
Problem. LXXIII.

Of a veſſell which containes three ſeverall kindes of liquor, all put in at one bung-hole, and drawn out at one tap ſeverally without mixture.

THe veſſell is thus made; it muſt be divided into three Cells for to conteine the three liquors, which admit to be Sack, Claret, and White-wine: Now in the bung-hole there is an Engine with three pipes, each extending to his proper Cell, into which there is put a broach or funnell pierced in three places, in ſuch ſort, that placing one of the holes right againſt the pipe which anſwereth unto him, the other two pipes are ſtopped; then when it is full, turne the funnel, and then the former hole will be ſtopped, and another open, to caſt in other wine without mixing it with the other.

Now to draw out alſo without mixture, at the bottome of the veſſell there muſt be placed a pipe or broach, which may have three pipes; and a cock pierſed with three holes, ſo artificially done, that turning the cock, the whole which anſwereth to ſuch of the pipes that is placed at the bottom, may iſſue forth ſuch wine as belongeth to that pipe, & turning the Cock to another pipe, the former hole will be ſtopped; and

and ſo there will iſſue forth another kinde of wine without any mixtures; but the Cocke may be ſo ordered that there may come out by it two wines together, or all three kindes at once: but it ſeems beſt when that in one veſſell and at one Cocke, a man may draw ſeverall kindes of wine; and which he pleaſeth to drink.



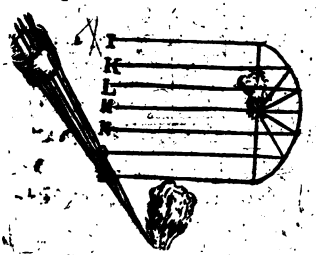
PROBLEM. LXXV.

Of burning-Glaſſes.

IN this inſuing diſcourſe I will ſhew the invention of *Prometheus*, how to ſteale fire from Heaven, and bring it down to the Earth; this is done by a little round Glaſſe, or made of ſteele, by which one may light a Candle, and make it flame, kindle Fire-brands to make them burne, melt Lead, Tinne, Gold, and Silver, in a little time: with as great eaſe as though it had been put into a Cruzet over a great fire.

Have you not read of *Archimedes* of *Syracuſa*, who when he could not come to the Ships of *Marcellus*, which beſieged that place, to hinder and impeach their aproach, he flung huge ſtones by his Ingines to ſink them into the Sea, and transformed himſelfe into *Jupiter*, thundering downe from the higheſt Towers of the

Town, his thunder-bolts of lightning into the Ships causing a terrible burning, in despite of Neptune and his watery region: *Zonaras* witnesseth that *Proclus* a brave Mathematician, burned in the same manner the Ships of *Vitalian*, which were come to besiege *Constantinople*; and daily experience may let you see great effects of burning: for a Bowle of Crystall polished, or a Glasse thicker in the middle than at the edges, will burne exceedingly, nay a bottle full of water exposed to the Sunne will burne, when the Sunne shineth hot, and children use with a Glasse to burne Flies which are against the walles, and their fellowes cloaths.



But this is nothing to the burning of those Glasses which are hollow, namely those which are of steele well polished, according to a parabolicall or ovall section: A sphericall Glasse, or that which is according to the segment of a *Sphere*, burnes very effectually about the fourth part of the Diameter; notwithstanding the Parabolie and Ecliptick sections have a great effect: by which Glasses there are also diverse figures represented forth to the eye.

The cause of this burning is the uniting of the beames of the Sunne, which heat mightily in the point of concourse or inflammation, which

which is either by transmission or reflection. Now it is pleasant to behold when one breatheth in the point of concourse, or throweth small dust there, or sprinkles vapours of hot water in that place; by which the Pyramidall point, or point of inflammation is knowne. Now some Authors promise to make Glasses which shall burne a great distance off, but yet not seen vulgarly produced, of which, if they were made, the Parabolie makes the greatest effect, and is generally held to be the invention of *Archimedes* or *Proclus*.

Maginus in the 5 *Chap.* of his Treatise of spherical Glasses, shewes how one may serve himselfe with a concave Glasse, to light fire in the shadow, or neare such a place where the Sunne shines not, which is by help of a flat Glasse, by which may be made a percussion of the beames of the Sun into the concave Glasse, adding unto it that it serves to good use to put fire to a Mine, provided that the combustible matter be well applyed before the concave Glasse; in which he saies true: but because all the effect of the practice depends upon the placing of the Glasse and the Powder which he speaks not of: I will deliver here a rule more generall.

How one may place a Burning-glasse with his combustible matter in such sort, that at a convenient houre of the day, the Sun shining, it shall take fire and burne: Now it is certaine

that the point of inflammation or burning, is changed as the Sun chargeth place; and no more nor leſſe, than the ſhadow turnes about the ſtyle of a Dyall; therefore have regard to the Suns motion, and his height and place: a Bowle of Cryſtall in the ſame place that the top of the ſtyle is, and the Powder or other combuſtible matter under the Meridian, or houre of 12, 1, 2, 3, &c. or any other houre, and under the Suns arch for that day: now the Sunne comming to the houre of 12, to 1, 2, 3, &c. the Sunne caſting his beames through the Cryſtall Bowle, will fire the materiall or combuſtible thing, which meets in the point of burning: the like may be obſerved of other Burning-glaſſes.

EXAMINATION.

IT is certaine in the firſt part of this Probleme that Cinicall, concave and ſpherical Glaſſes, of what matter ſoever, being placed to receive the beames of the Sun will excite heat, and that heat is ſo much the greater, by how much it is neere the point of concurſe or inflamation. But that Archimedes or Proclus did fire or burne Shipps with ſuch Glaſſes, the ancient Hiſtories are ſilent, yea themſelves ſay nothing: beſides the great difficultie that doth appeare in remoteneſſe, and the matter that the effects is to work upon. Now

by

by a comman Glasse we fire things neare at hand, from which it seems very facil to such which are lesse read, to do it at a farre greater distance, and so by relation some deliver to the World by supposition that which never was done in action: thus we say the rather, not to take away the most excellent and admirable effects which are in Burning-glasses, but to shew the variety of Antiquity and truth of History: and as touching to burne at a great distance, as is said of some, it is absolutely impossible, and that the Parabolicall and Ovall Glasses were of Archimedes and Proclus invention is much uncertaine: for besides the construction of such Glasses, they are more difficult than the obtuse concave ones are; and further, they hath not a great heat but neere at hand; for if it be cast farre off, the effect is little, and the beam weake, or otherwise. such Glasses must be greatly extended to contract many beames to amasse a sufficient quantity of beames in Parabolicall and Conicall Glasses, the point of inflammation ought to concur in a point, which is very difficult to be done in a due proportion. Moreover if the place be farre remote, as is supposed before, such a Glasse cannot be used but at a great inclination of

the Sunne, by which the effect of burning is diminished, by reason of the weakneſſe of the Sunne-beames.

And here may be noted in the laſt part of this Probleme, that by reaſon of obſtacles if one plaine Glaſſe be not ſufficient, a ſecond Glaſſe may be applyed to help it: that ſo if by one ſimple reflection it cannot be done, yet by a double reflection the Sun-beames may be caſt into the ſaid Caverne or Mine, and though the reflected beams in this caſe be weak, yet upon a fit combuſtible matter it will not faile to do the effect.

PROBLEM. LXXVI.

Containing many pleaſant Queſtions by way of Arithmeticke.

I Will not inſert in this Probleme that which is drawne from the Greek Epigrams, but propoſing the Queſtion immediately will give the anſwer alſo, without ſtaying to ſhew the manner how they are anſwered; in this I will not be tied to the Greek tearms, which I account not proper to this place, neither to my purpoſe: let thoſe read that will *Diophanta Schenbelius* upon *Euclide* and others, and they may be ſatisfied

Of the Aſſe and the Mule.

IT happened that the Mule and the Aſſe upon a day making a voyage each of them carried

a

a Barrell full of Wine: now the lasie Asse felt her selfe over-loaden, complained and bowed under her burthen; which the Mule seeing said unto her being angry, (for it was in the time when beasts spake) Thou great Asse, wherefore complaineſt thou? if I had but onely one measure of that which thou carrieſt, I should be loaden twice as much as thou art, and if I should give a measure of my loading to thee, yet my burthen would be as much as thine.

Now how many measures did each of them carry? Answer, the Mule did carry 7 measures, and the Asse 5 measures: for if the Mule had one of the measures of the Asses loading, then the Mule would have 8 measures, which is double to 4, and giving one to the Asse, each of them would have equall burthens: to wit, 6 measures apiece.

Of the number of Souldiers that fought before old Troy.

Homer being asked by *Hesiodus* how many Grecian Souldiers came against Troy? who answered him thus; The Grecians, said *Homer*, made 7 fires, or had 7 Kitchins, and before every fire, or in every Kitchin there were 50 broaches turning to roast a great quantitie of flesh, and each broach had meat enough to satisfie 900 men: now judge how many men there might be. Answer, 315000. that is, three hundred and fifteen thousand men, which is cleare by multiplying 7 by 50, and the product by 900 makes the said 315000.

Of the number of Crownes that two men had.

John and *Peter* had certaine number of crownes: *John* said to *Peter*, If you give me 10 of your crownes, I shall have three times as much as you have: but *Peter* said to *John*, If you give me 10 of your crownes I shall have 5 times as much as you have: how much had each of them? Answere, *John* had 15 crownes and 5 sevenths of a crowne, and *Peter* had 18 crownes, and 4 sevenths of a crowne. For if you adde 10 of *Peters* crownes to those of *Johns*, then should *John* have 25 crownes and 5 sevenths of a crowne, which is triple to that of *Peters*, viz: 8, and 4 sevenths: and *John* giving 10 to *Peter*, *Peter* should have then 28 crownes, and 4 sevenths of a crowne, which is *Quintuple*, or 5 times as much as *John* had left, *viz.* 5 crownes and 5 sevenths.

In like manner two Gamesters playing together, *A* and *B*, after play *A* said to *B*, Give me 2 crownes of thy money, and I shall have twice as much as thou hast: and *B* said to *A*, Give me 2 crownes of thy money, and I shall have 4 times as much as thou hast: now how much had each? Answer, *A* had 3 and 5 sevenths, and *B* had 4 and 6 sevenths.

Above

About the houre of the day.

SOme one asked a Mathemacian what a clocke it was; who answered that the reſt of the day is foure thirds of that which is paſt: now judge what a clock it is. Anſwer, if the day were according to the Jewes and ancient Romanes, which made it alwayes to be 12 houres, it was then the 5 houre, and one ſeventh of an houre, ſo there remained of the whole day $6\frac{6}{7}$ that is, 6 houres, and 6 ſeventhes of an hour. Now if you take the $\frac{4}{3}$ of $5\frac{1}{7}$ it is $\frac{12}{7}$ or 1 and $\frac{5}{7}$, which multiplied by 4 makes 6 and $\frac{5}{7}$, which is the remainder of the day, as before: but if the day had been 24 houres, then the houre had been 10 of the clock, and two ſeventhes of an houre, which is found out by dividing 12, or 24 by $\frac{7}{3}$.

There might have been added many curious propoſitions in this kinde, but they would be too difficult for the moſt part of people; therefore I have omitted them.

Of Pythagoras his Schollers.

PYthagoras being asked what number of Schollers he had, anſwered, that halfe of them ſtudied *Mathematickes*, the fourth part Phyſick, the ſeventh part Rethorick, and beſides he had 3 women: now judge you ſaith he, how many Schollers I have. Anſwer, he had in all 28, the halfe of which is 14, the quarter

of

of which is 7, [illegible] rt of which is which 14, 7, and [illegible] the other 3 to make up the 28. [illegible] men.

Of the number of Apples given amongst the Graces and the Muses.

THe three Graces carrying Apples upon a day, the one as many as the other, met with the 9 Muses, who asked of them some of their Apples; so each of the Graces gave to each of the Muses alike, and the distribution being made, they found that the Graces & the Muses had one as many as the other: The question is how many Apples each Grace had, and how many they gave to each Muse? To answer the question, joyne the number of Graces and Muses together which makes 12, and so many Apples had each Grace: Now may you take the double, triple, &c. of 12 that is 24, 36, &c. conditionally, that if each Grace had but 12, then may there be allotted to each Muse but one onely; if 24, then to each 2 Apples, if 36, then to each Muse 3 Apples, and so the distribution being made, they have a like number, that is one as many as the other.

Of the Testament or last will of a dying Father.

A Dying Father left a thousand Crownes amongst his two children; the one being legitimate, and the other a Bastard, conditionally

nally that the fifth part which his legittimate Sonne should have, should exceed by 10, the fourth part of that which the Bastard should have: what was each ones part? Answer, the legitimate Sonne had 577 crownes and $\frac{7}{9}$, and the Bastard 422 crownes and $\frac{2}{9}$ now the fifth part of 577 and 7 ninthes is 115, and $\frac{4}{9}$, and the fourth part of 422 and $\frac{2}{9}$ is 105 and $\frac{5}{9}$, which is lesse then 115 $\frac{4}{9}$ by 10, according to the Will of the *Testator*.

Of the Cups of Crœsus.

Crœsus gave to the Temple of the Gods six Cups of Gold, which weighed together 600 Drammes, but each cup was heavier then another by one Dram: how much did each of them therefore weigh? Answer, the first weighed 102 Drammes and a halfe; the second 101 Drammes and a halfe, the third 100 Drammes and $\frac{1}{2}$, the fourth 99 and halfe, the fifth 98 and a halfe; and the first Cup weighed 97 Drammes and a halfe. which together makes 600 Drams as before.

Of Cupids Apples.

Cupid complained to his mother that the Muses had taken away his Apples, *Clio*, said he, took from me the fifth part, *Euterp* the twelfth part, *Thalia* the eighth part, *Melpomene* the twentieth part, *Ermes* the seventh part, *Terpsichore* the fourth part, *Polyhymnia* took away 30, *Urania* 120, and *Caliope* 300. So

there

there vvere left me but 5 Appls, how many had he in all at the first? Answver 3360.

There are an infinite of such like questions amongst the Greek Epigrams: but it would be unpleasant to expresse them all: I will onely adde one more, and shew a generall rule for all the rest.

Of a Mans Age.

A Man vvas said to passe the sixth part of his life in childe-hood, the fourth part in his youth, the third part in Manhood, and 18 yeares besides in old age: what might his Age be? the answver is, 72 yeares: vvhich and all others is thus resolved: multiply ⅓ and ¼ together, that is, 6 by 4 makes 24, and that againe by 3 makes 72, then take the third part of 72, vvhich is 24, the fourth part of it, vvhich is 18, and the sixth part of it vvhich is 12, these added together make 54, vvhich taken from 72, rests 18, this divided by 1 8 (spoken in the Question) gives 1, which multiplied by the summe of the parts, viz. 72, makes 72, the Answver as before.

Of the Lion of Bronze placed upon a Fountaine with this Epigramme.

Out of my right eyen let vvater passe, I can fill the Cistenne in 3 dayes: if I let it passe out of the left eye, it vvill be filled in 2 dayes: if it passe out of my feet, the Cistern vvill be 4 dayes a filling; but if I let the vvater passe out of my mouth, I can fill the Cistern then in 6 houres.

houres: in what time should I fill it, if I poure forth the water at all the passages at once?

The Greeks (the greatest talkers in the world) variously apply this question to divers statues, and pipes of Fountaines: and the solution is by the Rule of 3, by a generall Rule, or by *Algebra*. They have also in their *Anthologie* many other questions, but because they are more proper to exercise, than to recreate the spirit, I passe them over (as before) with silence.

PROBLEM. LXXVII.

Divers excellent and admirable experiments upon Glasses.

THere is nothing in the world so beautifull as light; and nothing more recreative to the sight, than Glasses which reflect: therefore I will now produce some experiments upon them, not that I will dive into their depth (that were to lay open a mysterious thing) but that which may delight and recreate the spirits. Let us suppose therefore these principles, upon which is built the demonstration of the appearances which are made in all sort of Glasses.

First, that the rayes or beames, which reflect upon a Glasse, make the Angle of incident equall to the Angle of Reflection, by the first Theoreme of the *Catoptick* of *Euc.*

Secondly, that in all plain Glasses, the Images are seen in the perpendicular line to the Glasse,

as

as far within the glaſs as the object is without it.

Thirdly, in Concave, or Convex Glaſſes, the Images are ſeen in the right line which paſſeth from the object and through the Centre in the Glaſſe. Theo. 17. and 18.

And here you are to underſtand, that there is not meant only thoſe which are ſimple Glaſſes or Glaſſes of ſteele, but all other bodies, which may repreſent the viſible Image of things by reaſon of their reflection, as Water, Marble, Mettal, or ſuch like. Now take a Glaſſe in your hand and make experiment upon that which followeth.

Experiment upon flat and plaine Glaſſes.

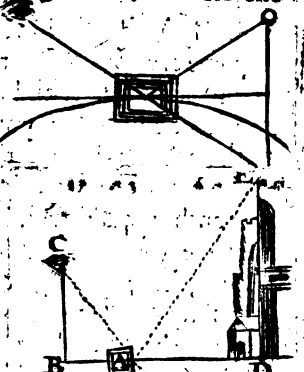
FIrſt, a man cannot ſee any thing in theſe Glaſſes, if he be not directly and in a perpendicular line before it, neither can he ſee an object in theſe Glaſſes, if it be not in ſuch a place, that makes the Angle of incidence equall to the Angle of reflexion: therefore when a Glaſſe ſtands upright, that is, perpendicular to the Horizon, you cannot ſee that which is above, except the Glaſſe be placed down flat: and to ſee that on the right hand, you muſt be on the left hand, &c.

Secondly, an image cannot be ſeen in a Glaſs if it be not raiſed above the ſurface of it; or place a Glaſſe upon a wall, you ſhall ſee nothing which is upon the plaine of the wall, and place it upon a Table or Horizontal Plaine, you ſhall ſee nothing of that which is upon the Table. Thirdly,

Thirdly, in a plaine Glaſſe all that is ſeene appeares or ſeemes to ſink behinde the Glaſſe, as much as the image is before the Glaſſe, as before is ſaid.

Fourthly, (as in water) a Glaſſe lying downe flat, or Horizontall, Towers, Trees, Men, or any height doth appeare, inverſed or upſide downe; and a Glaſſe placed upright, the right hand of the Jmage ſeems to be the left, and the left ſeems to be the right. Fifthly, will you ſee in a Chamber that which is done in the ſtreet, without being ſeen: then a Glaſſe muſt be diſpoſed, that the line upon which the Jmages come on the Glaſſe, make the Angle of incidence equall to that Angle of reflexion.

Sixtly, an height (as ſuppoſe *D E*.) may be meaſured by a plaine Glaſſe, as let the Glaſſe be *G* placed downe upon the ground, and let the eye be at *C*. ſo farre removed from the Glaſſe, that the eye at *C*. may ſee the toppe of the Tower *E* in the Angle or edge of the Glaſs at *A*, but in the line of reflexion *C A*, then meaſure the diſtance between your foot *B*, and the point *A*, & alſo the diſtance betweene the Glaſſe *A*, and the foot of the Tower *D*, viz. *A D*. Now as often as *A B* is found in *A D*, ſo often doth the height of ther



Tower

Tower *E D* contain the diſtance from your eye to the foot, *viz.* *C B* for the Triangles *A,B,C*, and *A,D,E*, are equal Triangles: therefore as *B A.* to *A D*, ſo *C B*, to *E D*, or alternately as *B A.* to *B C*, ſo *A D.* to *D E.*

Seventhly, preſent a Candle upon a plaine Glaſſe, and look flaunting upon it, ſo that the Candle and the Glaſſe be neere in a right line, you ſhall ſee 3, 4, 5, &c. images, from one and the ſame Candle.

Eighthly, take two plaine Glaſſes, and hold them one againſt the other, you ſhall alternately ſee them oftentimes one within the other, yea within themſelves, againe and againe.

Ninthly, if you hold a plaine Glaſſe behinde your head, and another before your face, you may ſee the hinder part of your head, in that Glaſſe which you hold before your face.

Tenthly, you may have a fine experiment if you place two Glaſſes together, that they make an acute angle, and ſo the leſſer the angle is, the more apparances you ſhall ſee, the one direct, the other inverſed, the one approaching, and the other retiring.

Eleventhly, it is a wonder & aſtoniſhment to ſome, to ſee within a Glaſſe an Image without knowing from whence it came, and it may be done many wayes: as place a Glaſs higher than the eye of the beholder, and right againſt it is ſome Image; ſo it reſteth not upon the beholder, but doth caſt the Image upwards. Then place another object, ſo that it reflect, or caſt

the

the Image downeward to the eye of the ſpectator, without perceiving it being hid behinde ſomething, for then the Glaſſe will repreſent a quite contrary thing, either that which is before the Glaſſe, or that which is about it, to wit, the other hidden object.

Twelfthly, if there be ingraved behinde the backſide of a Glaſſe, or drawne any Image upon it, it will appeare before as an Image, without any appearance: or portraicture to be perceived.

EXAMINATION.

THis 12 Article *of ingraving an Image behinde the Glaſſe, will be of no great conſequence, becauſe the lineaments will ſeem ſo obſcure, but if there were painted ſome Image, and then that covered according to the uſuall covering of Glaſſes behinde, and ſo made up like an ordinary looking-Glaſſe having an Image in the middle, in this reſpect it would be ſufficiently pleaſant: and that which would admire the ignorant, and able to exerciſe the moſt ſubtilleſt, and that principally if the Glaſſe be in an obſcure place, and the light which is given to it be ſomewhat farre off.*

PLace a Glaſſe neare the floor of a Chamber, & make a hole through the place under the Glaſſe, ſo that thoſe which are below may not perceive it, and diſpoſe a bright Image under

the hole ſo that it may caſt his ſpecies upon the Glaſſe, and it will cauſe admiration to thoſe which are below that know not the cauſe; The ſame may be done by placing the Image in a Chamber adjoyning, and ſo make it to be ſeen upon the ſide of the Wall.

14 In theſe Channel-Images which ſhew one ſide a deaths head, & another ſide a faire face: and right before ſome other thing: it is a thing evident, that ſetting a plaine Glaſſe ſidewiſe to this Image you ſhall ſee it in a contrary thing, then that which was preſented before ſidewiſe.

15 Laſtly, it is a fine ſecret to preſent unto a plaine Glaſſe writing with ſuch induſtry, that one may read it in the Glaſſe, and yet out of the Glaſſe there is nothing to be known, which will thus happen, if the writing be writ backward: but that which is more ſtrange, to ſhew a kinde of writing to a plaine Glaſſe, it ſhall appear another kinde of writing both againſt ſenſe and forme, as if there were preſented to the Glaſſe WEL, it would ſhew it MET; if it were written thus MIV, and preſented to the Glaſſe, it would appeare thus VIM; for in the firſt, if the Glaſſe ly flat, then the things are inverſed that are perpendicular to the Glaſs, if the Glaſs and the object be upright, then that on the right hand, is turned to the left, as in the latter.

And here I ceaſe to ſpeak further of theſe plaine Glaſſes, either of the Admirable multiplications, or appearances, which is made in a great number of them; for to content the ſight

in

in this particular, one muſt have recourſe to the Cabinets of great Perſonages who incrich themſelves with moſt beautifull ones.

Experiments upon Gibbous, or convex Spherical Glaſſes.

IF they be in the forme of a Bowle, or part of a great Globe of Glaſſe, there is ſingular contentment to contemplate on them.

Firſt, becauſe they preſent the objects leſſe and more gracious, and by how much more the Images are ſeparated from the Glaſſe, by ſo much the more they diminiſh in Magnitude.

Secondly, they that ſhew the Images plaiting, or foulding, which is very pleaſant, eſpecially when the Glaſſe is placed downe, and behold in it ſome Blanching, ſeeling, &c. The upper part of a Gallerie, the porch of a Hall, &c. for they will be repreſented as a great veſſel having more belly in the middle then at the two ends, and Poſts, and Joiſts of Timber will ſeeme as Circles.

Thirdly, that which raviſheth the ſpirits, by the eye, and which ſhames the beſt perſpective Painting that a Painter can make, is the beautifull contraction of the Images, that appeare within the ſphericity of theſe ſmall Glaſſes: for preſent the Glaſſe to the lower end of a Gallarie, or at the Corner of a great Court full of People; or towards a great ſtreet, Church, fortification, an Army of men, to a whole Cittie; all the faire Architecture, and appearances will

be ſeene contracted within the circuit of the Glaſſe with ſuch varietie of Colours, and diſtinctions in the leſſer parts, that I know not in the world what is more agreeable to the ſight, and pleaſant to behold, in which you will not have an exact proportion, but it will be variable, according to the diſtance of the Object from the Glaſſe.

Exptriments upon hollow, or Concave Spherical Glaſſes.

I Have heretofore ſpoken how they may burne, being made of Glaſſe, or Metall, it remaines now that I deliver ſome pleaſant uſes of them, which they repreſent unto our ſight, and ſo much the more notable it will be, by how much the greater the Glaſſe is, and the Globe from whence it is extracted for it muſt in proportion as a ſegment of ſome be made circle or orbe.

EXAMINATION.

IN this we may obſerve that a ſection of 2. 3. or 4. Inches in diameter, may be ſegments of ſpheres of 2. 3. or 4. foot, nay of ſo many fadome, for it is certaine that amongſt thoſe which comprehend a great portion of a leſſer ſphere, and thoſe which comprehend a little ſegment of a great ſpheere, whether they be equall or not in ſection, there will happen an evident difference in one and the ſame expe-

riment,

riment, in the number, ſituation, quantitie, and figure of the Images of one or many different objects, and in burning there is a great difference.

Maginus, in a little Tractate that he had upon theſe Glaſſes, witneſſeth of himſelfe that he hath cauſed many to be poliſhed for ſundry great Lords of *Italy*, and *Germanie*, which were ſegments of Globes of 2. 3. and 4. foot diameter; and I wiſh you had ſome ſuch like to ſee the experiments of that which followeth; it is not difficult to have ſuch made, or bought here in Town, the contentment herein would beare with the coſt.

EXAMINATION.

Touching Maginus *he hath nothing aydedme to the knowledge of the truth by his extract out of* Vitellius, *but left it: expecting it from others, rather than to be plunged in the ſearch of it himſelfe, affecting rather the forging of the matter, and compoſition of the Glaſſes, than Geometrically to eſtabliſh their effects.*

FIrſt therefore in concave Glaſſes, the Images are ſeene ſometimes upon the ſurface of the Glaſſes, ſometimes as though they were within it and behinde it, deeply ſunk into it, ſometimes they are ſeene before, and without the Glaſſe, ſometimes between the object and the

Glaſſe: ſometimes in the place of the Eye, ſometimes farther from the Glaſſe then the object is: which comes to paſſe by reaſon of the divers concourſe of the beames, and change of the place of the Images in the line of reflection.

EXAMINATION.

THe relation of theſe appearances paſſe current amongſt moſt men, but becauſe the curious may not receive prejudice in their experiments, ſomething ought to be ſaid thereof to give it a more lively touch: in the true cauſes of theſe appearances, in the firſt place it is impoſſible that the Image *can be upon the ſurface of the* Glaſſe, *and it is a principall point to declare truly in which place the* Image *is ſeen in the* Glaſſe: *thoſe that are more learned in* Opticall *knowledge affirme the contrary, and nature it ſelfe gives it a certaine place according to its poſition, being alwayes ſeen in the line of reflection, which* Alhazen, Vitellius, *and others full of great knowledge, have confirmed by their writings: but in their particular they were too much occupied by the authority of the Ancients, who were not ſufficiently circumſpect in experience, upon which the principles of this ſubject ought to be built, and ſearched not fully into the true cauſe of theſe appearances, ſeeing they leave unto poſterities many falſities in their writings, and thoſe that followed them*

them for the moſt part fell into the like errors.

As for the Images *to bide in the eye, it cannot be but is impertinent and abſurd; but it followeth that, by how much neerer the object approacheth to the* Glaſſe, *by ſo much the more the appearances ſeem to come to the eye: and if the eye be without the point of concourſe, and the object alſo; as long as the object approacheth thereto, the repreſentation of the* Image *cometh neere the eye, but paſſing the point of concourſe it goes back againe: theſe appearances thus approaching do not a little aſtoniſh thoſe which are ignorant of the cauſe: they are inverſed, if the eye be without the point of concourſe until the object be within, but contrarily if the eye be between the point of concourſe and the* Glaſſe, *then the* Images *are direct: and if the eye or the object be in the point of concourſe, the* Glaſſe *will be enlightened, and the* Images *confuſed, and if there were but a ſpark of fire in the ſaid point of concourſe, all the* Glaſſe *would ſeeme a burning* fire-brand, *and we dare ſay it would occurre without chance, and in the night be the moſt certaine and ſubtileſt light that can be, if a candle were placed there: And whoſoever ſhall enter into the ſearch of the truth of new experiments in this ſubject, without doubt he will confirme what we here ſpeak of: & will finde new lights with a conveniable poſition to the* Glaſſe, *he will have reflection of quantities, of truth, and fine ſecrets in nature, yet not known, which he may eaſily comprehend*

if he have but an indifferent ſight, and may aſſure himſelfe that the Images cannot exceed the ſight, nor trouble it, a thing too much abſurd to nature.

And it is an abſolute verity in this ſcience, that the eye being once placed in the line of reflection of any object, and moved in the ſame line: the object is ſeene in one and the ſame place immoueable; or if the Image and the eye moue in their owne lines, the repreſentation in the Glaſſe ſeemes to inveſt it ſelfe continually with a different figure.

NOw the Image comming thus to the eye, thoſe which know not the ſecret, draw their ſword when theyſee an Image thus to iſſue out of the Glaſſe, or a Piſtoll which ſome one holds behinde: and ſome Glaſſes will ſhew a ſword wholly drawne out, ſeparated from the Glaſſe, as though it were in the aire: and it is daily exerciſed, that a man may touch the Image of his hand or his face out of the Glaſſe, which comes out the farther, by how much the Glaſſe is great and the Centre remote.

EXAMINATION.

NOw that a Piſtoll being preſented to a Glaſſe behinde a man, ſhould come out of the Glaſſe, and make him afraid that ſtands before, ſeeming to ſhoot at him, this cannot be: for no object whatſoever preſented

preſented to a concave Glaſſe, if it be not neerer to the Glaſſe then the eye is, it comes not out to the ſight of the party; therefore he needs not feare that which is ſaid to be behinde his back, and comes out of the Glaſſe; for if it doth come out, it muſt then neceſſarily be before his face, ſo in a concave Glaſſe whoſe Centre is farre remote, of a ſword, ſtick, or ſuch like be preſented to the Glaſſe, it ſhall totally be ſeen to come forth of the Glaſſe and all the hand that holds it. And here generally note, that if an Image be ſeen to iſſue out of the Glaſſe to come towards the face of any one that ſtands by, the object ſhall be likewiſe ſeen to thruſt towards that face in the Glaſs and may eaſily be knowne to all the ſtanders by: ſo many perſons ſtanding before a Glaſſe, if one of the company take a ſword, and would make it iſſue forth towards any other that ſtands there: let him chuſe his Image in the Glaſſe and carry the ſword right towards it, and the effect will follow. In like manner ones hand being preſented to the Gloſſe, as it is thruſt towards the Centre, ſo the repreſentation of it comes towards it, and ſo the hands will ſeeme to be united, or to touch one another.

FRom which may be concluded, if ſuch a Glaſſe be placed at the ſeeling or planching of a Hall, ſo that the face be *Horizontall* and look downward; one may ſee under it as it were a man hanging by the feet, and if there were many placed ſo, one could not enter into that place without great feare or ſcaring: for one

one ſhould ſee many men in the *aire* as if they were hanging by the feet.

EXAMINATION.

TOuching a Glaſſe *tyed at a ſeeling or plan-ching, that one may ſee a man hang by the feet in the* aire *and ſo many* Glaſſes, *many men may be ſeen: without caution this is very abſurd, the for if the* Glaſſe *or* Glaſſes *be not ſo great that Centre of the ſphe are upon which it was made, extend not neere to the head of him that is under it, it will not pleaſantly appeare, and though the* Glaſſe *ſhould be of that capacity that the* Centre *did extend ſo farre, yet will not the* Images *be ſeene to them which are from the* Glaſſe *but only to thoſe which are under it, or neere unto it: and to them it will not ably appeare, and it would be moſt admirable to have a* Gallerie *vaulted over with ſuch* Glaſſes *which would wonderfully aſtoniſh any one that enters into it: for all the things in the Gallery would be ſeen to hang in the* aire *and you could not walk without incountering airie apparitions.*

SEcondly; in flat or plaine Glaſſes the Image is ſeen equall to his object, and to repreſent a whole man, there ought to be a Glaſſe as great as the Image is: In convex Glaſſes the Images are ſeen alwaies leſſe, in concave Glaſſes they

they may be ſeen greater or leſſer, but not truly proportionable, by reaſon the diverſe reflexions which contracts or inlargeth the Species: when the eye is between the Centre and the ſurface of the Glaſſe; the Image appeares ſometimes very great and deformed, and thoſe which have but the appearance of the beginning of a beard on their chinne, may cheare up themſelves to ſee they have a great beard; thoſe that ſeeme to be faire will thruſt away the Glaſſe with deſpight, becauſe it will transforme their beauty: thoſe that put their hand to the Glaſſe vvill ſeeme to have the hand of a Giant, and if one puts his finger to the Glaſſe it vvill be ſeen as a great *Pyramide* of fleſh, inverſed againſt his finger.

Thirdly, it is a thing admirable that the eye being approached to the point of concourſe of the Glaſſe, there vvill be ſeen nothing but an intermixture or confuſion: but retiring back a little from that point, (becauſe the rayes do there meet,) he ſhall ſee his Image inverſed, having his head belovv and his feet above.

Fourthly, the divers appearances cauſed by the motion of objects, either retiring or approaching: whether they turne to the right hand or to the left hand, whether the Glaſſe be hung againſt a wall, or whether it be placed upon a Pavement, as alſo what may be repreſented by the mutuall aſpect of concave Glaſſes with plaine and convex Glaſſes: but I will with ſilence paſſe them over, only ſay ſomething of two rare experiments more as followeth.

The

The first is to represent by help of the Sun, such letters as one would upon the front of a house: so that one may read them: *Maginus* doth deliver the way thus. Write the Letters, saith he, sufficiently bigge, but inversed upon the surface of the Glasse, with some kinde of colour, or theseletters may be written with wax, (the easier to be taken out againe:) for then placing the Glasse to the Sunne, the letters which are written there will be reverberated or reflected upon the Wall: hence it was perhaps that *Pythagoras* did promise with this invention to write upon the Moone.

In the second place, how a man may sundry wayes help himselfe with such a Glasse, with a lighted Torch or Candle, placed in the point of concourse or inflammation, which is neare the fourth part of the Diameter: for by this meanes the light of the Candle will be reverberated into the Glasse, and will be cast back againe very farre by parrallel lines, making so great a light that one may clearly see that which is done farre off, yea in the camp of an Enemie: and those which shall see the Glasse a farre off, will think they see a Silver Basin inlightened, or a fire more resplendent then the Torch. It is this way that there are made certaine Lanthorns which dazell the eyes of those which come against them; yet it serves singular well to enlighten those which carry them, accommodating a Candle with a little hollow Glasse: so that it may successively be applyed to the point of inflammation.

In

In like manner by this reflected light, one may reade farre off, provided that the letters be indifferent great, as an Epitaph placed high, or in a place obscure; or the letter of a friend which dares not approach without perill or suspition.

EXAMINATION.

THis will be scarce sensible upon a wall remote from the Glasse, and but indifferently seen upon a wall which is neare the Glasse, and withall it must be in obscuritie or shadowed, or else it will not be seen. To cast light in the night to a place remote, with a Candle placed in the point of concourse or inflammation, is one of the most notablest properties which can be shewne in a concave Glasse: for if in the point of inflammation of a parabolicall section, a Candle be placed, the light will be reflected by parallel lines, as a columne or Cylinder; but in the sphericall section it is defective in part, the beames being not united in one point, but somewhat scattering: notwithstanding it casteth a very great beautifull light.

LAstly, those which feare to hurt their sight by the approach of Lampes or Candles, may by this artifice place at some corner of a Chamber, a Lamp with a hollow Glasse behinde it,

it, which will commodiouſly reflect the light upon a *Table*, or to a place aſſigned: ſo that the *Glaſſe* be ſomewhat raiſed to make the light to ſtreeke upon the Table with ſharp Angles, as the Sunne doth when it is but a little elevated above the *Horizon*, for this light ſhall exceed the light of many Candles placed in the Roome, and be more pleaſant to the ſight of him that uſeth it.

Of other Glaſſes of pleaſure.

Firſt, the *Columnary* and *Pyramidall Glaſſes* that are contained under right lines, do repreſent the *Images* as plaine *Glaſſes* do; and if they be bowing, then they repreſent the *Image*, as the concave and convex *Glaſſes* doe.

Secondly, thoſe *Glaſſes* which are plaine, but have aſcents of Angels in the middle, will ſhew one to have foure Eyes, two Mouthes, two Noſes, &c.

EXAMINATION.

These experiments will be found different according to the diverſe meeting of the Glaſſes, *which commonly are made ſcuing-wiſe at the end, by which there will be two divers ſuperficies in the* Glaſſe, *making the exteriour Angle ſomewhat raiſed, at the interiour onely one ſuperficies, which*

may

may be covered according to ordinary Glaſſes *to cauſe a reflexion, and ſo it will be but one* Glaſſe, *which by refraction according to the different thickneſſe of the* Glaſſe, *and different Angles of the ſcuing forme, do differently preſent the Images to the eye, as foure eyes, two mouthes, two noſes; ſometimes three eyes one mouth, and one noſe, the one large and the other long, ſometimes two eyes onely: with the mouth and the noſe deformed, which the* Glaſſe *(impenetrable) will not ſhew. And if there be an interiour ſolid Angle, according to the difference of it, (as if it be more ſharp) there will be repreſented two diſtinct double Images, that is, two entire* viſages, *and as the Angle is open, by ſo much the more the double Images will reunite and enter one within another, which will preſent ſometimes a whole viſage extended at large, to have foure eyes, two noſes, and two mouthes: and by moving the* Glaſſe *the Angle will vaniſh, and ſo the two ſuperficies will be turned into one, and the duplicity of Images will alſo vaniſh and appeare but one onely: and this is eaſily experimented with two little* Glaſſes *of Steel, or ſuch like ſo united, that they make divers Angles and inclinations.*

THirdly, there are *Glaſſes* which make men ſeeme *pale, red,* and coloured in diverſe manners, which is cauſed by the dye of the *Glaſſe*, or the diverſe refraction of the *Species*: and thoſe which are made of *Silver, Latine, Steele*, &c. do give the *Images* a diverſe colour alſo.

In

In which one may ſee that the appearances by ſome are made fairer, younger or older than they are; and contrarily others will make them foule and deformed: and give them a contrary viſage: for if a Glaſſe be cut as it may be, or if many pieces of Glaſſe be placed together to make a conveniable reflexion; there might be made of a Mole (as it were) a mountaine, of one Haire a Tree, a Fly to be as an Elephant, but I ſhould be too long if I ſhould ſay all that which might be ſaid upon the property of Glaſſes. I will therefore conclude this diſcourſe of the properties of theſe Glaſſes with theſe foure recreative Problemes following.

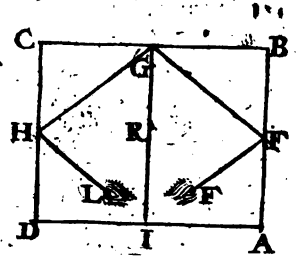
PROBLEM. LXXVIII.

How to ſhew to one that is ſuſpitious, what is done in another Chamber or Roome: notwithſtanding the interpoſition of the wall.

FOr the performance of this, there muſt be placed three Glaſſes in the two Chambers, of which one of them ſhall be tyed to the planching or ſeeling, that it may be common to communicate the Species to each Glaſſe by reflexion, there being left ſome hole at the top of the Wall againſt the Glaſſe to this end: the two other Glaſſes muſt be placed againſt the two Walls at right Angles, as the figure here ſheweth at *B.* and *C.*

Then

Then the ſight at *E* by the line of incidence *F E*, ſhall fall upon the Glaſſe *B A*, and reflect upon the ſuperficies of the Glaſſe *B C*, in the point *G*; ſo that if the eye be at *G*, it ſhould ſee *E*, and *E* would reflect upon the third Glaſs in the point *H*, and the eye that is at *L*, will ſee the Image that is at *E*. in the point of the *Cathet*: which Image ſhall come to the eye of the ſuſpicious, *viz.* at *L*. by help of the third Glaſſe, upon which is made the ſecond reflexion, and ſo brings unto the eye the object, though a wall be between it.



Corolarie. 1.

BY this invention of reflections the beſiegers of a Towne may be ſeene upon the Rampart: notwithſtanding the Parapet, which the beſieged may do by placing a Glaſſe in the hollow of the Ditch, and placing another upon the toppe of the wall, ſo that the line of incidence comming to the bottom of the Ditch, make an Angle equall to the Angle of reflexion, then by this ſituation and reflexion, the Image of the beſiegement will be ſeen to him is upon the Rampart.

Corolarie 2.

BY which alſo may be inferred, that the ſame reflexions may be ſeen in a Regular *Polygon*, and placing as many Glaſſes as there are ſides, counting two for one; for then the object being ſet to one of the Glaſſes, and the eye in the other, the Jmage will be ſeen eaſily.

Corolarie 3.

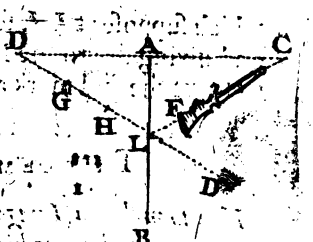
FArther, notwithſtanding the interpoſition of many Walls, Chambers, or Cabinets, one may ſee that which paſſeth through the moſt remoteſt of them, by placing of many Glaſſes as there are openings in the walls, making them to receive the incident angles equall: that is, placing them in ſuch ſort by ſome Geometricall aſſiſtant, that the incident points may meet in the middle of the Glaſſes: but here all the defect will be, that the Jmages paſſing by ſo many reflexions, will be very weak and ſcarce obſervable.

PROBLEM LXXIX.

How with a Muſket to ſtrike a mark, not looking towards it, as exact as one aiming at it.

AS let the eye be at *O*, and the mark *C*, place a plaine Glaſſe perpendicular as *A B*. ſo the marke *C* ſhall be ſeen in *Cathet C A*, viz.

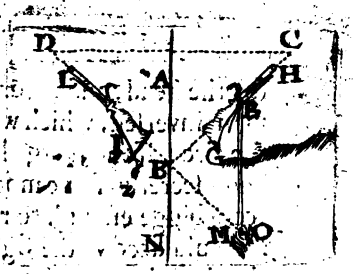
in *D*, and the line of reflexion is *D*, now let the Musket *F E*, upon a reſt, be moved to and fro untill it be ſeen in the line *O D*, which admit to be *HG*, ſo giving fite to the Musket, it ſhall undoubtedly ſtrike the mark.



Corolaries.

From which may be gathered, that one may exactly ſhoot out of a Musket to a place which is not ſeen, being hindered by ſome obſtacle, or other interpoſition.

AS let the eye be at *M*, the mark *C*, and the wall which keeps it from being ſeene, admit to be *Q R*, then ſet up a plaine Glaſs as *A B*, and let the Musket by *G H*, placed upon his reſt *P O*. Now becauſe the marke *C* is ſeen at *D*, move the Musket to and fro, untill it doth agree with the line of reflection *MB*,

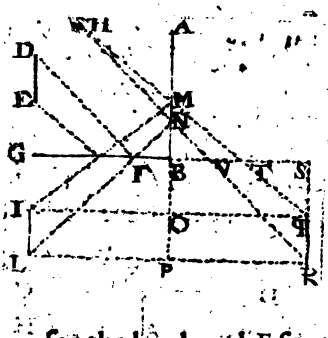


which ſuppoſe at *L I*, ſo ſhall it be truly placed, and giving fire to the Musket, it ſhall not faile to ſtrike the ſaid mark at *C*.

PROBLEM. LXXX.

How to make an Image to be ſeen hanging in the aire, having his head downeward.

TAke two Glaſſes, and place them at right Angles one unto the other, as admit *A B*, and *C B*, of which admit *C B*, *Horizontall*, and let the eye be at *H*, and the object or image to be *D E*; ſo *D* will be reflected at *F*, ſo to *N*, ſo to *H E*: then at *G*, ſo to *M* and then to *H*, and by a double reflection *E D* will ſeeme in *Q R*, the higheſt point *D* in *R*, and the point *E* in *Q* inverſed as was ſaid, taking *D* for the head, and *E* for the feet; ſo it will be a man inverſed, which will ſeem to be flying in the aire, if the Image had wings unto it, and had ſecretly ſome motion: and if the Glaſſe were bigge enough to receive many reflexions, it would deceive the ſight the more by admiring the changing of colours that would be ſeen by that motion.

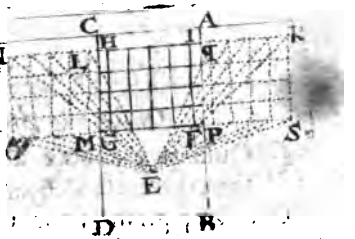


PROB.

PROBLEM. LXXXI.

How to make a company of repreſentative Souldiers ſeeme to be a Regiment, or how few in number may be multiplyed to ſeem to be many in number.

TO make the experiment upon men, there muſt be prepared two great Glaſſes; but in ſtead of it we will ſuppoſe two leſſer, as *G H.* and *F I*, one placed right againſt another perpendicular to the *Horizon*, upon a plaine levell Table: betvveene vvhich Glaſſes let there be ranged in Battalia-vviſe upon the ſame Table a number of ſmall men according to the ſquare *G,H,I,F*, or in any other forme or poſture; then may you evidently ſee hovv the ſaid battel vvill be multiplyed and ſeem farre bigger in the appearance than it is in effect.



Corolarie.

BY this invention you may make a little Cabinet of foure foot long, and tvvo foot large, (more or leſſe) vvhich being filled vvith

Rockes or ſuch like things, or there being put into it Silver, Gold, Stones of luſter, Jewels, &c. and the walls of the ſaid Cabinet being all covered or hung with plaine glaſſe; theſe viſibles will appeare manifoldly increaſed, by reaſon of the multiplicitie of reflexions, and at the opening of the ſaid Cabinet, having ſet ſomething which might hide them from being ſeen, thoſe that look into it will be aſtoniſhed to ſee ſo few in number which before ſeemed to be ſo many.

PROBLEM. LXXXII.

Of fine and pleaſant Dyals.

COuld you chooſe a more ridiculous one than the natural *Dyall* written amongſt the Greek Epigrams, upon which ſome lewd Poet made verſes; ſhewing that a man carrieth about him alwayes a *Dyall* in his face by meanes of the Noſe and Teeth? and is not this a jolly *Dyall*? for he need not but open the mouth, the lines ſhall be all the teeth, and the noſe ſhall ſerve for the ſtyle.

Of a Dyall of hearbes.

CAn you have a finer thing in a Garden, or in the middle of a Compartement, than to ſee the lines and the number of houres repreſented with little buſhie hearbes, as of Hyſope

or

or ſuch which is proper to be cut in the borders; and at the top of the ſtyle to have a Fanne to ſhew which way the winde bloweth? this is very pleaſant and uſefull.

Of the Dyall upon the fingers and the hand.

IS is nor a commoditie very agreeable, when one is in the field, or in ſome village vvithout any other *Dyall*, to ſee onely by the hand vvhat of the clock it is? vvhich gives it very neare; and may be practiſed by the left hand, in this manner.

Take a ſtravv or like thing of the length of the *Index*, or the ſecond finger, hold this ſtraw very right betvveen the thumb and the fore-finger, then ſtretch forth the hand and turne your back, and the palm of your hand tovvard's the Sunne; ſo that the ſhadovv of the muſcle vvhich is under the Thumb, touch the line of life, vvhich is betvveen the middle of the tvvo other great lines, vvhich is ſeen in the palme of the hand, this done, the end of the ſhadovv vvill ſhevv vvhat of the clock it is: for at the end of the firſt finger it is 7 in the morning, or 5 in the evening, at the end of the Ring-finger it is 8 in the morning, or 4 in the evening, at the end of the little finger or firſt joynt, it is 9 in the morning, or 3 in the after-noone, 10 & 2 at the ſecond joynt, 11 and 1 at the third joynt; and midday in the line followving, vvhich comes from the end of the *Index*.

Of a Dyall which was about an Obeliske at Rome.

WAs not this a pretty fetch upon a pavement, to chooſe an *Obeliske* for a *Dyall*, having 106 foot in height, without removing the Baſis of it? *Plinie* aſſures us in his 36 book and 8 *Chap.* that the Emperour *Auguſtus* having accommodated in the field of *Mars* an *Obeliske* of this height, he made about it a pavement, and by the induſtry of *Manilius* the Mathemetician, there were enchaced markes of Copper upon the Pavement, and placed alſo an Apple of Gold upon the toppe of the ſaid *Obeliske*, to know the houre and the courſe of the Sunne, with the increaſe and decreaſe of dayes by the ſame ſhadow: and in the ſame manner do ſome by the ſhadow of their head or other ſtyle, make the like experiments in Aſtronomie.

Of Dyals with Glaſſes.

PTolomie writes, as *Cardanus* reports, that long ago there were Glaſſes which ſerved for *Dyals*, and preſented the face of the beholder

holder as many times as the houre ought to be, twice if it were 2 of the clock, 9 if it were 9, &c. But this was thought to be done by the help of water, and not by Glaſſes, which did leake by little and little out of the veſſell, diſcovering anon one Glaſſe, then anon two Glaſſes, then 3, 4, 5 Glaſſes, &c. to ſhew ſo many faces as there were houres, which was onely by leaking of water.

Of a Dyall which hath a Glaſſe in the place of the Style.

WHat will you ſay of the invention of Mathematicians, which finde out daily ſo many fine and curious novelties? they have now a way to make *Dyals* upon the wainſcot or ſeeling of a Chamber, and there where the Sunne can never ſhine, or the beames of the Sunne cannot directly ſtrike: and this is done in placing of a little Glaſſe in the place of the ſtyle which reflecteth the light, with the ſame condition that the ſhadow of the ſtyle ſheweth the houre: and it is eaſie to make experiment upon a common *Dyall*, changing only the diſpoſition of the *Dyall*, and tying to the end of the ſtyle a piece of plaine Glaſſe. The *Almaines* uſe it much, who by this way have no greater trouble, but to put their Noſes out of their beds and ſee what a clock it is, which is reflected by a little hole in the Window upon the wall or ſeeling of the Chamber.

EXA-

EXAMINATION.

IN this there are two experiments considerable, the first is with a very little Glasse placed so that it may be open to the beames of the Sunne, the other hath respect to a spacious or great Glasse placed to a very little hole so that the Sun may shine on it, for then the shadow which is cast upon the Dyall is converted into beames of the Sunne, and will reflect and becast upon a plain opposite; and in the other it is a hole in the window or such like, by which may passe the beames of the Sun, which represent the extreamity of the style, & the Glasse representeth the plaine of the Dyall, upon which the beames being in manner of shadowes reflect cast upon a plaine opposite: and it is needfull that in this second way the Glasse may be spacious, as before, to receive the delineaments of the Dyall. Otherwise you may draw the lineaments of a Dyall upon any plaine looking-glasse which reflecteth the Sunne-beames, for the applying a style or a pearle at the extreamitie of it, and placed to the Sunne, the reflexion will be answerable to the delineaments on the Glasse: but here note, that the Glasse ought to be great, and so the delineaments thereon.

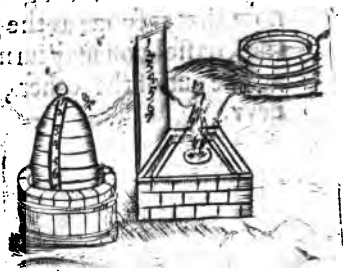
But

But that which is most noble, is to draw houre-lines upon the outside of the Glasse of a window, and placing a style thereto upon the outside; the shadow of the style will be seen within, and so you have the hour, more certaine without any difficulty.

Of Dyals with water.

SVch kinde of Dyals were made in ancient times, and also these of sand: before they had skill to make Sun-dyals or Dyals with wheeles; for they used to fill a vessell with water, and having experience by tryall that it would runne out all in a day, they did marke within the vessell the houres noted by the running of the water; and some did set a peece of light board in the vessell to swimme upon the top of the water, carrying a little statue, which with a small stick did point out the houre upon a columne or wall, figured with houre-notes, as the vessell was figured within.

Vitruvius writes of another manner of water-Dyal more difficult; and *Baptista à Porta* amongst his naturall secrets, delivers this invention following. Take a vessel full of water like a caldron, & another vessell of glasse alike unto a Bell, (with which some accustome to cover *Melons*:) and let this



Vessell

veſſell of Glaſſe be almoſt as great as the Caldron, having a ſmall hole at the bottome, then when it is placed upon the vvater, it vvill ſink by little and little: by this one may marke the houres on the ſurface of the Glaſſe to ſerve another time. But if at the beginning one had drawn the water vvithin the ſame veſſell of Glaſſe in ſucking by the little hole, the vvater vvould not fall out, but as faſt as the aire vvould ſucceed it, entering ſlovvly at the little hole: for contrarily the houres may be diſtinguiſhed by diminution of water, or by augmentation.

Novv it ſeemes a ſafer vvay that the vvater paſſe out by drop and drop, and drop into a Cylindricall Glaſſe by help of a Pipe: for having marked the exterior part of the Cylinder in the houre notes, the vvater it ſelfe vvhich falls vvithin it, vvill ſhevv vvhat of the clock it is, farre better than the running of ſand, for by this may you have the parts of the houres moſt accurate, vvhich commonly by ſand is not had: and to vvhich may be added the houres of other Countreys vvith greater eaſe. And here note, that as ſoone as the vvater is out of one of the Glaſſes, you may turne it over into the ſame againe out of the other, and ſo let it runne anevv.

PROB.

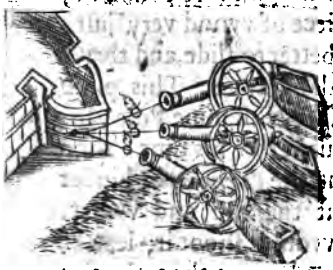
PROBLEM. LXXXIII.

Of Cannon-vv. great Artillery. Souldiers, and others would willingly see this Probleme, which containes three or foure subtile questions: The first is, how to charge a Cannon without powder?

THis may be done vvith aire and vvater, only having throvvn cold vvater into the Cannon, vvhich might be squirted forceably in by the closure of the mouth of the Piece, that so by this pressure the aire might more condense; then having a round piece of vvood very just, and oiled vvell for the better to slide, and thrust the Bullet vvhen it shall be time: This piece of vvood may be held fast vvith some Pole, for feare it be not thrust out before his time: then let fire be made about the *Trunion* or hinder part of the Piece to heat the aire and vvater, and then vvhen one vvould shoot it, let the pole be quickly loosened, for then the aire searching a greater place, and having vvay now offered, vvill thrust out the vvood and the bullet very quick: the experiment vvhich vve have in long trunkes shooting out pellats vvith aire only, shevveth the verity of this Probleme.

2 *In the ſecond queſtion it may be demanded, how much time doth the Bullet of a Cannon ſpend in the aire before it falls to the ground?*

THe reſolution of this Queſtion depends upon the goodneſſe of the Piece & charge thereof, ſeeing in each there is great difference. It is reported that *Tycho Brahe*, and the *Landſgrave* did make an experiment upon a Cannon in Germany, which being charged and ſhot off; the Bullet ſpent two minutes of time in the aire before it fell; and the diſtance was a Germane mile, which diſtance proportionated to an hours time, makes 120 Italian miles.



3 *In the third queſtion it may be asked, how it comes to paſſe, that a Cannon ſhooting upwards, the Bullet flies with more vidlence than being ſhot point-blanke, or ſhooting downeward?*

IF we regard the effect of a Cannon when it is to batter a wall, the Queſtion is falſe, ſeeing it is moſt evident that the blowes which fall perpendicular upon a wall, are more violent than thoſe which ſtrike byas-wiſe or glaunſingly.

But

But conſidering the ſtrength of the blow only, the Queſtion is moſt true, and often experimented to be found true: a Piece mounted at the beſt of the Randon, which is neare halfe of the right, conveyes her Bullet with a farre greater violence then that which is ſhot at point blanke, or mounted parallel to the Horizon. The common reaſon is, that ſhooting high, the fire carries the bowle a longer time in the aire, and the aire moves more facill upwards, than dovvnevvards, becauſe that the airy circles that the motion of the bullet makes, are ſooneſt broken. Hovvſoever this be the generall tenet, it is curious to finde out the inequality of moving of the aire, vvhether the Bullet fly upvvard, dovvnevvard, or right forvvard, to produce a ſenſible differehce of motion, & ſome think that the Cannon being mounted, the Bullet preſſing the povvder maketh a greater reſiſtance, and ſo cauſeth all the Povvder to be inflamed before the Bullet is throvvne out, vvhich makes it to be more violent than othervviſe it vvould be. When the Cannon is otherviſe diſpoſed, the contrary arives, the fire leaves the Bullet, and the Bullet rolling from the Povvder reſiſts leſſe: and it is uſually ſeene, that ſhooting out of a Muſket charged onely vvith Povvder, to ſhoot to a marke of Paper placed Point blanke, that there are ſeene many ſmall holes in the paper, vvhich cannot be other than the graines of Powder which did not take fire: but this latter accident may happen

from

from the over-charging of the Piece, or the length of it, or windy, or dampeneſſe of the Powder.

From which ſome may think, that a Cannon pointed right to the *Zenith*, ſhould ſhoot with greater violence, then in any other mount or forme whatſoever: and by ſome it hath beene imagined that a Bullet ſhot in this faſhion hath been conſumed, melted, and loſt in the Aire, by reaſon of the violence of the blow, and the activity of the fire, and that ſundry experiments have been made in this nature, and the Bullet never found. But it is hard to believe this aſſertion: it may rather be ſuppoſed that the Bullet falling farre from the Piece cannot be diſcerned where it falls: and ſo comes to be loſt.

4. In the fourth place it may be asked, whether the diſcharge of a Cannon be ſo much the greater, by how much it is longer?

IT ſeemeth at the firſt to be moſt true, that the longer the Piece is, the more violent it ſhoots: and to ſpeak generally, that which is direction by a Trunke, Pipe, or other concavitie, is conveyed ſo much the more violent, or better, by how much it is longer, either in reſpect of the Sight, Hearing, Water, Fire, &c. & the reaſon ſeems to hold in Cannons, becauſe in thoſe that are long, the fire is retained a longer time in the concavitie of the Piece, and ſo throwes

throwes out the Bullet with more violence; and experience lets us see that taking Cannons of the same boare, but of diversitie of length from 8 foot to 12, that the Cannon of 9 foot long hath more force than that of 8 foot long, and 10 more than that of 9, and so unto 12 foote of length. Now the usuall Cannon carries 600 Paces, some more, some lesse, yea some but 200 Paces from the Piece, and may shoot into soft earth 15 or 17 foot, into sand or earth which is loose, 22 or 24 foot, and in firme ground, about 10 or 12 foot, &c.

It hath been seen lately in Germany, where there were made Pieces from 8 foot long to 17 foot of like boare, that shooting out of any piece which was longer than 12 foot; the force was diminished, and the more in length the Piece increaseth, the lesse his force was: therefore the length ought to be in a meane measure, and it is often seene, the greater the Cannon is, by so much the service is greater: but to have it too long or too short, is not convenient, but a meane proportion of length to be taken, otherwise the flame of the fire will be over-prest with Aire: which hinders the motion in respect of substance, and distance of getting out.

N PRO

PROBLEM. LXXXIIII.

Of prodigious progreſſion and multiplication, of Creatures, Plants, Fruits, Numbers, Gold, Silver, &c. when they are alwayes augmented by certaine proportion.

HEre we ſhall ſhew things no leſſe admirable, as recreative, and yet ſo certaine and eaſie to be demonſtrated, that there needs not but Multiplication only, to try each particular: and firſt,

Of graines of Muſtard-ſeed.

FIrſt, therefore it is certaine that the increaſe of one graine of Muſtard-ſeed for 20 yeares ſpace, cannot be contained within the viſible world, nay if it were a hundred times greater than it is: and holding nothing beſides from the Centre of the earth even unto the firmament, but only ſmall grains of Muſtard-ſeed: Now becauſe this ſeems but words, it muſt be proved by Art, as may be done in this wiſe, as ſuppoſe one Muſtard-ſeed ſowne to bring forth a tree or branch, in each extendure of which might be a thouſand graines: but we will ſuppoſe onely a thouſand in the whole tree, and let us proceed to 20 yeares, every ſeed to bring forth yearely a thouſand graines, now multiplying alwayes by a thouſand, in leſſe then 17 years you

you ſhall have ſo many graines which will ſurpaſſe the ſands, which are able to fill the whole firmament: for following the ſuppoſition of *Archimedes*, and the moſt probable opinion of the greatneſs of the firmament which *Tycho Brahe* hath left us; the number of graines of ſand will be ſufficiently expreſſed with 49 Ciphers; but the number of graines of Muſtard-ſeed at the end of 17 yeares will have 52 Ciphers: and moreover, graines of Muſtard-ſeed, are farre greater than theſe of the ſands: it is therefore evident that at the ſeventeenth yeare, all the graines of Muſtard-ſeed which ſhall ſucceſſively ſpring from one graine onely, cannot be contained within the limits of the whole firmament; what ſhould it be then, if it ſhould be multiplied againe by a thouſand for the 18 yeare: and that againe by a thouſand for every yeares increaſe untill you come to the 20 yeare, it's a thing as cleare as the day, that ſuch a heap of Muſtard-ſeed would be a hundred thouſand times greater than the Earth: and bring onely but the increaſe of one graine in 20 yeares.

Of Pigges.

SEcondly, is it not a ſtrange propoſition, to ſay that the great Turke with all his Revenues, is not able to maintaine for one yeares time, all the Pigges that a Sow may pigge with all her race, that is, the increaſe with the increaſe unto 12 years: this ſeemes impoſſible, yet it is moſt true, for let us ſuppoſe and put the caſe,

that a Sow bring forth but 6, two Males, and 4 Females, and that each Female ſhall bring forth as many every yeare, during the ſpace of 12 yeares, at the end of the time there will be found above 33 millions of Pigges: now allowing a crowne for the maintenance of each Pigge for a yeare, (which is as little as may be, being but neare a halfe of a farthing allowance for each day;) there muſt be at the leaſt ſo many crownes to maintaine them, one a yeare, *viz.* 33 millions, which exceeds the Turkes revenue by much.

Of graines of Corne.

THirdly, it will make one aſtoniſhed to think that a graine of Corne, with his increaſe ſucceſſively for the ſpace of 12 yeares will produce in grains 244140625000000000000, which is able to load almoſt all the creatures in the World.

To open which, let it be ſuppoſed that the firſt yeare one graine being ſowed brings forth 50, (but ſometimes there is ſeen 70, ſometimes 100 fold) which graines ſowen the next yeare, every one to produce 50, and ſo conſequently the whole and increaſe to be ſowen every yeare, until 12 yeares be expired, there will be of increaſe the aforeſaid prodigious ſumme of graines, *viz.* 244140625000000000000, which will make a cubical heap of 62658522 graines every way, which is more than a cubicall body of 31 miles every way: for allowing 40 graines

in

in length to each foot; the Cube would be 156463 foot every way: from which it is evident that if there were two hundred thousand Cities as great as *London*, allowing to each 3 miles square every way, and 100 foot in height, there would not be sufficient roome to containe the aforesaid quantitie of Corne: and suppose a bushel of Corne were equal unto two Cubicke feet, which might containe twenty hundred thousand graines, then would there be 1220704625000000. bushells, and allowing 30 bushels to a Tunne, it would be able to load 813803083 vessels; which is more than eight thousand one hundred and thirty eight millions, ship loadings of 500 Tunne to each ship a quantity so great that the Sea is scarce able to beare, or the universal world able to finde vessels to carry it. And if this Corne should be valued at halfe a crown the bushel, it would amount unto 1525880781250opounds sterling, which I think exceeds all the Treasures of all the Princes, and of other particular men in the whole world: and is not this good husbandry to sowe one grain of Corne; and to continue it in sowing, the increase only for 12 yeares to have so great a profit?

Of the increase of Sheep.

FOurthly, those that have great flocks of Sheep may be quickly rich, if they would preserve their Sheep without killing or selling of them: so that every Sheep produce one each

yeare, for at the end of 16 yeares, 100 Sheepe will multiply and increaſe unto 655360, which is above 6 millions, 5 hundred 53 thouſand Sheep: now ſuppoſing them worth but a crown apiece, it would amount unto 1638400 pounds ſterling, vvhich is above 1 million 6 hundred 38 thouſand pounds, a faire increaſe of one Sheep: and a large portion for a Childe if it ſhould be allotted.

Of the increaſe of Codfiſh, Carpes, &c.

FIfthly, if there be any creatures in the vvorld that do abound vvith increaſe or fertilitie, it may be rightly attributed to fiſh; for they in their kindes produce ſuch a great multitude of Eggs, and brings forth ſo many little ones, that if a great part vvere not deſtroyed continually, vvithin a ittle vvhile they vvould fill all the Sea, Ponds, and Rivers in the vvorld; and it is eaſie to ſhevv hovv it vvould come ſo to paſſe, onely by ſuppoſing them to increaſe without taking or deſtroying them for the ſpace of 10 or 12 yeares: having regard to the ſoliditie of the waters which are allotted for to lodge and containe theſe creatures, as their bounds and place of reſt to live in.

Of the increaſe and multiplication of men.

SIxthly, there are ſome that cannot conceive how it can be that from eight perſons (which were

were ſaved after the deluge or *Noahs* flood) ſhould ſpring ſuch a world of people to begin a Monarchie under *Nimrod*, being but 200 yeares after the flood, and that amongſt them ſhould be raiſed an army of two hundred thouſand fighting men: But it is eaſily proved if vve take but one of the Children of *Noah*, and ſuppoſe that a nevv generation of people begun at every 30 yeares, and that it be continued to the ſeventh generation vvhich is 200 yeares; for then of oneonly family there vvould be produced one hundred and eleven thouſand ſoules, three hundred and five to begin the vvorld: though in that time men lived longer, and vvere more capable of multiplication and increaſe; vvhich number ſpringing onely from a ſimple production of one yearly, vvould be farre greater, if one man ſhould have many vvives, vvhich in ancient times they had: from vvhich it is alſo that the Children of *Iſrael*, vvho came into Egypt but onely 70 ſoules, yet after 210 yeares captivity, they came forth vvith their hoſtes, that there vvere told ſix hundred thouſand fighting men, beſides old people, women and children; and he that ſhall ſeparate but one of the families of *Joſeph*, it would be ſufficient to make up that number: how much more ſhould it be then if we ſhould adjoyne many families together?

Of the increaſe of numbers.

SEventhly, what ſumme of money ſhall the City of *London* be worth, if it ſhould be ſold, and the money be paid in a yeare after this

manner: the first week to pay a pinne, the second week 2 pinnes, the third week 4 pinnes, the fourth week 8 pinnes, the fifth week 16 pinnes. and so doubling untill the 52 weeks, or the yeare be expired.

Here one would think that the value of the pinnes would amount but to a small matter, in comparison of the Treasures, or riches of the whole City: yet it is most probable that the number of pinnes would amount unto the sum of 4519599628681215, and if we should allow unto a quarter a hundred thousand pinnes, the whole would contain ninetie eight millions, foure hundred thousand Tunne: which is able to load 45930 Shippes of a thousand Tunne apiece: and if we should allow a thousaud pins for a penny, the summe of money would amount unto above eighteen thousand, eight hundred and thirty millions of pounds sterling, an high price to sell a Citie at, yet certain, according to that first proposed. So if 40 Townes were sold upon condition to give for the first a penny, for the second 2 pence, for the third 4 pence, &c. by doubling all the rest unto the last, it would amount unto this number of pence, 1099511627776, which in pounds is 4581298444, that is foure thousand five hundred and fourescore millions of pounds and more.

Of

Of a man that gathered up Apples, Stones, or ſuch like upon a condition.

EIghtly, admit there were an hundred Apples, Stones, or ſuch like things that were plac'd in a ſtraight line or right forme, a Pace one from another, and a basket being placed a Pace from the firſt: how many paces would there be made to put all theſe Stones into the basket, by fetching one by one? this would require neer halfe a day to do it, for there would be made ten thouſand and ninety two paces before he ſhould gather them all up.

Of Changes in Bells, in muſicall Inſtruments, tranſmutation of places, in numbers, letters, men or ſuch like.

NInethly, is it not an admirable thing to conſider how the skill of numbers doth eaſily furniſh us with the knowledge of myſterious and hidden things? which ſimply looked into by others that are not verſed in Arithmetick, do preſent unto them a world of confuſion and difficultie.

As in the firſt place, it is often debated amongſt our common Ringers, what number of Changes there might be made in 5,6,7,8, or more Bells: who ſpend much time to anſwer their owne doubts, entring often into a Labyrinth in the ſearch thereof: or if there were 10 voyces, how many ſeverall notes might there be?

be? Theſe are propoſitions of ſuch facility, that a childe which can but multiply one number by another, may eaſily reſolve it, which is but only to multiply every number from the unite ſucceſſively in each others product, unto the terme aſſigned: ſo the 6 number that is againſt 6 in the Table, is 720, and ſo many Changes may be made upon *6 Bells*, upon 5 there are 120, &c.

In like manner againſt 10 in the Table is 3628800, that is, three millions, ſix hundred twenty eight thouſand, eight hundred: which ſhews that 10 voices may have ſo many conſorts, each man keeping his owne note, but only altering his place; and ſo of ſtringed Inſtruments, and the *Gamat* may be varied according to which, anſwerable to the number againſt *X*, viz. 1124001075070399680000 notes, from which may be drawne this, or the like propoſition. Suppoſe that 7 Schollers were taken out of a free Schoole to be ſent to an *Univerſitie*, there to be entertained in ſome *Colledge* at commons for a certaine ſumme of money, ſo that each of them have two meales daily, and no longer to continue there, then that ſitting all together upon one bench or forme at every meale, there might be a divers tranſmutation of place, of account in ſome one of them, in compariſon of another, and never the whole company to be twice alike in ſituation: how long may the Steward entertaine them? (who being not ſkilled in this fetch may anſwere unadviſedly.) It is moſt certaine that there will be

five

five thousand and forty seuerall positions or changings in the seatings, which maks 14 years time wanting 10 weeks and 3 dayes. Hence from this mutability of transmutation, it is no marvell that by 24 letters there ariseth and is made such variety of languages in the world, & such infinite number of words in each language; seeing the diversity of syllables produceth that effect, and also by the interchanging & placing of letters amongst the vowels, & amongst themselves maketh these syllables: vvhich Alphabet of 24 letters may be varied so many times, *viz.* 6204485934388606233600000 vvhich is six hundred tvventy thousand, foure hundred forty eight millions of millions of millions five hundred ninety three thousand, foure hundred thirty eight milions of milions, & more.

1	*a*	1
2	*b*	2
6	*c*	3
24	*d*	4
120	*e*	5
720	*f*	6
5040	*g*	7
40320	*h*	8
362880	*i*	9
3628800	*k*	10
39916800	*l*	11
479001600	*m*	12
6227020800	*n*	13
87178291200	*o*	14
1307674368000	*p*	15
20922789888000	*q*	16
355687537996000	*r*	17
6402375683928000	*s*	18
121645137994632000	*t*	19
2433902759892640000	*u*	20
51090957957745440000	*w*	21
1124001075070399680000	*x*	22
25852024726619264000000	*y*	23
620448592438860623360000000	*z*	24

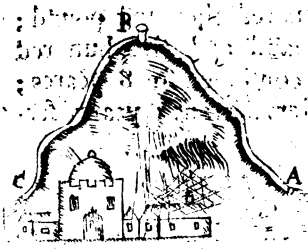
Novv allovving that a man may reade or speak one hundred thousand vvords in an houre vvhich is tvvice more vvords than there are contained

PROBLEM. LXXXV.

Of Fountaines, Hydriatiques, Machinecks, and other experiments upon water, or other liquor.

1. *First how to make Water at the foot of a mountaine to aſcend to the top of it, and ſo to deſcend on the other ſide?*

TO do this there muſt be a Pipe of lead, which may come from the fountaine *A*, to the top of the Mountaine *B*; and ſo to deſcend on the other ſide a little lower then the Fountaine, as at *C*: then make a hole in the Pipe at the top of the Mountaine, as at *B*, and ſtop the end of the Pipe at *A* and *C*; and fill this Pipe at *B* with water: & cloſe it very carefully againe at *B*, that no aire get in: then unſtop the end at *A*, & at *C*; then will the water perpetually runne up the hill, and deſcend on the other ſide, which is an invention of great conſequence to furniſh Villages that want water.



2. *Secondly,*

2. *Secondly, how to know what Wine or other liquor there is in a veſſell without opening the bung-hole, and without making any other hole, than that by which it runnes out at the top?*

IN this problem there is nothing but to take a bowed pipe of Glaſſe, and put it into the faucets hole, and ſtopping it cloſe about: for then you ſhall ſee the wine or liquor to aſcend in this Pipe, untill it be juſt even with the liquor in the veſſel; by which a man may fill the veſſel, or put more into it: and ſo if need were, one may empty one veſſel into another without opening the bung-hole.

3. *Thirdly, how is it that it is ſaid that a veſſell holds more water being placed at the foot of a Mountaine, than ſtanding upon the top of it?*

THis is a thing moſt certaine, becauſe that water and all other liquor diſpoſeth it ſelfe ſphericaliy about the Centre of the earth; and by how much the veſſel is nearer the Centre, by ſo much the more the ſurface of the water makes a leſſer ſphere, and therefore every part more *gibbous* or ſwelling, than the like part in a greater ſphere: and therefore when the ſame veſſell is farther from the Centre of the earth, the ſurface of the water makes a greater ſphere, and therefore leſſe *gibbous*, or ſwelling over the veſſel;

veſſell: from whence it is evident that a veſſell near the Centre of the Earth holds more water than that which is farther remote from it; and ſo conſequently a veſſel placed at the bottome of the Mountaine holds more water, than being placed on the top of the Mountaine. Firſt, therefore one may conclude, that one and the ſame veſſel will alwayes hold more: by how much it is nearer the Centre of the earth. Secondly, if a veſſell be very neare the Centre of the earth, there will be more water above the brims of it, than there is within the veſſel. Thirdly, a veſſel full of water comming to the Centre wil ſpherically increaſe, and by little and little leave the veſſel; and paſſing the Centre, the veſſel will be all emptied. Fourthly, one cannot carry a Paile of water from a low place to a higher, but it will more and more run out and over, becauſe that in aſcending it lies more levell, but deſcending it ſwels and becomes more *gibbous*.

4. *Fourthly, to conduct water from the top of one Mountaine, to the top of another.*

AS admit on the top of a Mountaine there is a ſpring, and at the toppe of the other Moun-

Mountaine there are Inhabitants which want water now to make a bridge from one Mountaine to another, were difficult and too great a charge; by way of Pipes it is easie and of no great price: for if at the ſpring on the top of the Mountaine be placed a Pipe, to deſcend into the valley, and aſcend to the other Mountlaine, the water will runne naturally, and continually, provided that the ſpring be ſomewhat higher than the paſſage of the water at the Inhabitants.

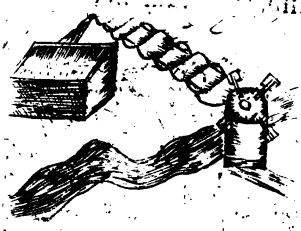
5. *Fifthly, of a fine Fountaine which ſpouts water very high, and with great violence by turning of a Cock.*

LEt there be a veſſell as *A B*, made cloſe in all his parts, in the middle of which let *C D* be a Pipe open at *D* neare the bottome, and then with a Squirt ſquirt in the water at *C*, ſtopped above by the cock or faucet *C*, with as great violence as poſſible you can; and turne the cock immediatly. Now there being an indifferent quantity of water and aire in the veſſel, the water keeps it ſelfe in the bottome, and the aire, which was greatly preſſed, ſeeks for more place, that

turning the Cock the water issueth forth at the Pipe, and flyes very high, and that especially if the vessell be a little heated: some make use of this for an Ewer to wash hands withall; and therefore putting a moveable Pipe above C, such as the figure sheweth: which the water will cause to turne very quick, pleasurable to behold.

6. *Sixtly of Archimedes screw, which makes water ascend by descending.*

THis is nothing else but a Cylinder, about the which is a Pipe in form of a screw, and when one turnes it, the water descends alwayes in respect of the Pipe: for it passeth from one part which is higher to that which is lower, and at the end of the Engine the water is found higher than it was at the spring. This great Engineer admirable in all Mathematicall Arts invented this Instrument to wash King *Hieros* great vessell: as some Authors saye, also to water the fields of Egypt, as *Diodorus* witnesseth: and *Cardanus* reporteth that a Citizen of *Milan* having made the like Engine, thinking himselfe to be the first inventer, conceived such exceeding joy, that he became mad, *foll.* 2.

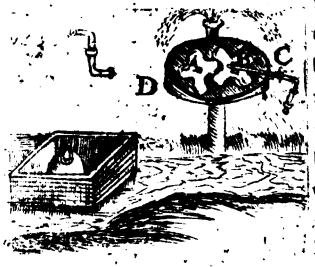


Againe a thing may ascend by descending, if

if a ſpiral line be made having many circulations or revolutions; the laſt being alwayes leſſer than the firſt, yet higher than the Plaine ſuppoſed: it is moſt certaine that then putting a ball into it, and turning the ſpirall line ſo, that the firſt circulation may be perpendicular, or touch alwayes the ſuppoſed Plain: the ball ſhall in deſcending continually aſcend, untill at laſt it come to the higheſt part of the ſpirall line, & ſo fall out. And here eſpecially may be noted, that a moving body as water, or a Bullet, or ſuch like, will never aſcend if the Helicall revolution of the ſcrew be not inclining to the Horizon: ſo that according to this inclination the ball or liquor, may deſcend alwayes by a continuall motion and revolution. And this experiment may be more uſefull, naturally made with a thred of Iron, or Latine turned or bowed Helically about a Cylinder, with ſome diſtinction of diſtances between the *Helices*, for then having drawn out the Cylinder, or having hung or tyed ſome weight at it in ſuch ſort, that the water may eaſily drop if one lift up the ſaid thred: theſe *Helices* or revolutions, notwithſtanding will remaine inclining to the Horizon, and then turning it about forward, the ſaid weight will aſcend, but backward it will deſcend. Now if the revolutions be alike, and of equallity amongſt themſelves, and the whirling or turning motion be quicke, the ſight will be ſo deceived, that producing the action it will ſeeme to the ignorant no leſſe than a Miracle.

7. Seventhly, of another fine Fountaine of pleasure.

THis is an Engine that hath two wheeles with Cogges, or teeth as *A B*, which are placed within an Ovall *C D*, in such sort, that the teeth of the one, may enter into the notches of the other; but so just that neither aire nor water may enter into the Ovall coffer, either by the middle or by the sides, for the wheele must joyne so neare to the sides of the coffer, that there be no vacuitie: to this there is an axeltree with a handle to each wheele, so that they may be turned, and *A* being turned, that turneth the other wheele that is opposite: by which motion the aire that is in *E*, & the water that is carried by the hollow of the wheeles of each side, by continuall motion, is constrained to mount and flie out by the funnell *F*: now to make the water runne what way one would have it, there may be applied upon the top of the Pipe *F*, two other moveable Pipes inserted one within another; as the figure sheweth. But here note, that there may acrue some inconveniency in this Machine seeing that by quick turning the Cogges



or teeth of the wheeles running one againſt another, may neare break them, and ſo give way to the aire to enter in, which being violently incloſed will eſcape to occupie the place of the water, whoſe weight makes it ſo quick: howſoever, if this Machine be curiouſly made as an able workeman may eaſily do, it is a moſt ſovereigne Engine, to caſt water high and farre off for to quench fires. And to have it to raine to a place aſſigned, accommodate a ſocket having a Pipe at the middle, which may point towards the place being ſet at the top thereof, and ſo having great diſcretion in turning the Axis of the wheele, it may work exceeding well, and continue long.

8. *Eighth, of a fine watering pot, for gardens.*

THis may be made in forme of a Bottle according to the laſt figure or ſuch like, having at the bottome many ſmall holes, and at the neck of it another hole ſomewhat greater than thoſe at the bottome, which hole at the top you muſt unſtop when you would fill this watering pot, for then it is nothing but putting the lower end into a paile of water, for ſo it will fill it ſelfe by degrees: and being full, put your thumb on the hole at the neck to ſtop it, for then may you carry it from place to place, and it will not ſenſibly runne out, ſomething it will, and all in time (if it were never ſo cloſe ſtopped) contrary to the ancient tenet in Philoſophy, that aire will not penetrate.

9. Ninthly, how eaſily to take wine out of a veſſell at the bung-hole, without piercing of a hole in the veſſell?

IN this there is no need but to have a Cane or Pipe of Glaſſe or ſuch like, one of the ends of which may be cloſed up almoſt, leaving ſome ſmall hole at the end; for then if that end be ſet into the veſſell at the bung-hole, the whole Cane or Pipe will be filled by little and little, and once being full, ſtop the other end which is without and then pull out the Cane or Pipe, ſo will it be ful of wine, then opening a little the top above, you may fill a Glaſſe or other Pot with it, for as the Wine iſſueth out, the aire commeth into the Cane or Pipe to ſupply vacuity.

10. Tenthly, how to meaſure irregular bodies by help of water?

SOme throw in the body or magnitude into a veſſell, and keep that which floweth out over, ſaying it is always equal to the thing caſt into the water: but it is more neater this way to poure into a veſſell ſuch a quantity of water, hich

which may be thought ſufficient to cover the body or magnitude, and make a marke how high the water is in the veſſell, then poure out all this water into another veſſell, and let the body or magnitude be placed into the firſt veſſel; then poure in water from the ſecond veſſell, until it aſcend unto the former marke made in the firſt veſſell, ſo the water which remaines in the ſecond veſſel is equall to the body or magnitude put into the water: but here note that this is not exact or free from error, yet nearer the truth than any Geometrician can otherwiſe poſſibly meaſure, and theſe bodies that are not ſo full of pores are more truly meaſured this way, than others are.

11. *To finde the weight of water.*

SEeing that $\frac{574}{1000}$ part of an ounce weight, makes a cubicall inch of water: and every pound weight *Haverdepoize* makes 27 cubicall inches, and $\frac{9}{12}$ *fere*, and that 7 Gallons and a halfe wine meaſure makes a foot cubicall, it is eaſie by inverſion, that knowing the quantity of a veſſel in *Gallons*, to finde his content in cubicall feet or weight: and that late famous *Geometrician* Maſter *Brigs* found a cubical foot of water to weigh neare 62 pound weight *Haverdepoize*. But the late learned *Simon Stevin* found a cubicall foot of water to weigh 65 pound, which difference may ariſe from the inequalitie of water; for ſome waters are more ponderous than others, and ſome difference

may be from the weight of a pound, and the measure of a foot: thus the weight and quantitie of a solid foot settled, it is easie for Arithmeticians to give the contents of vessells or bodies which containe liquids.

12. *To finde the charge that a vessell may carry as Shippes, Boates, or such like.*

THis is generally conceived, that a vessell may carry as much weight as that water weigheth, which is equall unto the vessell in bignesse, in abating onely the weight of the vessell: we see that a barrel of wine or water cast into the water, will not sink to the bottome, but swim easily, and if a ship had not iron and other ponderosities in it, it might swim full of water without sinking: in the same manner if the vessell were loaden with lead, so much should the watter weigh: hence it is that Mariners call Shippes of 50 thousand Tunnes, because they may containe one or two thousand Tunne, and so consequently carry as much.

13. *How comes it that a Shippe having safely sayled in the vast Ocean, and being come into the Port or harbour, without any tempest will sink down right?*

THe cause of this is that a vessel may carry more upon some kinde of water than upon other; now the water of the Sea is thicker and heavier than that of Rivers, Wels, or Fountains; there-

therefore the loading of a veſſell which is accounted ſufficient in the Sea, becomes too great in the harbour or ſweet water. Now ſome think that it is the depth of the water that makes veſſells more eaſie to ſwimme, but it is an abuſe; for if the loading of a Ship be no heavier than the water that would occupie that place, the Ship ſhould as eaſily ſwim upon that water, as if it did ſwim upon a thouſand fathom deep of water, and if the vvater be no thicker than a leafe of paper, and weigheth but an ounce under a heavy body, it vvill ſupport it, as vvell as if the vvater under it vveighed ten thouſand pound vveight: hence it is if there be a veſſell capable of a little more than a thouſand pound vveight of vvater, you may put into this veſſell a piece of vvood, vvhich ſhall vveigh a thouſand pound vveight; (but lighter in his kinde than the like of magnitude of vvater:) for then pouring in but a quart of vvater or a very little quantitie of vvater, the vvood vvill ſvvim on the top of it, (provided that the vvood touch not the ſides of the veſſell:) vvhich is a fine experiment, and ſeems admirable in the performance.

14. *How a groſſe body of mettle may ſwimme upon the water?*

THis is done by extending the mettle into a thin Plate, to make it hollovv in forme of a veſſel; ſo that the greatneſſe of the veſſell which the aire vvith it containeth, be equal to the

the magnitude of the water, which weighes as much as it, for all bodies may swim without sinking, if they occupie the place of water equal in weight unto them, as if it weighed 12 pound it must have the place of 12 pound of water: hence it is that we see floating upon the water great vessells of copper or Brasse, when they are hollow in forme of a Caldron. And how can it be otherwise conceived of Islands in the Sea that swim and float? is it not that they are hollow and some part like unto a Boat, or that their earth is very light and spongious, or having many concavities in the body of it, or much wood within it.

And it would be a pretty proposition to shew how much every kinde of metall should be inlarged, to make it swim upon the water: which doth depend upon the proportion that is between the weight of the water and each metall. Now the proportion that is betweene metalls and water of equall magnitude, according to some Authors, is as followeth.

	Gold 187 ½
A magnitude of 10 pound	*Lead* 116 ½
weight of water will require	*Silver* 104
for the like magnitude of	*Copper* 91
	Iron 81
	Tinne 75

From which is inferred, that to make a piece of Copper of 10 pound weight to swimme, it must be so made hollow, that it may hold 90 times that weight of water and somewhat more, that is to say, 91 pound: seeing that Copper

per and water of like magnitudes in their ponderosities, are as before, as 9 to 8.

15. *How to weigh the lightneſſe of the aire?*

PLace a Ballance of wood turned upſide downe into the water, that ſo it may ſwim, then let water be incloſed within ſome body as within a Bladder or ſuch like, and ſuppoſe that ſuch a quantitie of aire ſhould weigh one pound, place it under one of the Ballances, and place under the other as much weight of lightneſſe as may counter-ballance and keep the other Ballance that it riſe not out of the water: by which you ſhall ſee how much the lightneſſe is.

But without any Ballance do this; take a Cubicall hollow veſſell, or that which is *Cylindricall*, which may ſwimme on the water, and as it ſinketh by placing of weights upon it, marke howv much, for then if you vvould examine the vveight of any body, you have nothing to do but to put it into this veſſell, and marke howv deep it ſinkes, for ſo many pound it vveighes as the vveights put in do make it ſo to ſinke.

16. *Being*

16. Being given a body, to marke it about, and ſhew how much of it will ſink in the water, or ſwim above the water.

THis is done by knovving the vveight of the body vvhich is given, and the quantity of vvater, vvhich vveighes as much as that body; for then certainly it vvill ſink ſo deep, untill it occupieth the place of that quantitie of vvater.

17. To finde how much ſeverall mettle or other bodies doe weigh leſſe in the water than in the aire:

TAke a Ballance, & vveigh (as for example) 9 pound of Gold, Silver, Lead, or Stone in the aire, ſo it hang *in æquilibrio*; then comming to the vvater, take the ſame quantity of Gold Silver, Lead, or Stone, and let it ſoftly dovvne into it, and you ſhall ſee that you ſhall need a leſſe counterpoiſe in the other Ballance to counter-ballance it; vvherefore all ſolids or bodies vveigh leſſe in the vvater than in the aire, and ſo much the leſſe it vvill be, by hovv much the vvater is groſſe and thick, becauſe the vveight findes a greater reſiſtance, and therefore the vvater ſupports more than aire; and further, becauſe the vvater by the ponderoſitie is diſpleaſed, and ſo ſtrives to be there againe, preſſing to it, by reaſon of the other vvaters that are about it, according to the proportion of his

his weight. *Archimedes* demonſtrateth, that all bodies weigh leſſe in the water (or in like liquor) by how much they occupie place: and if the water weigh a pound weight, the magnitude in the water ſhall weigh a pound leſſe than in the aire.

Now by knowing the proportion of water and mettles, it is found that Gold loſeth in the water the 19 part of his weight, Copper the 9 part, Quickſilver the 15 part, Lead the 12 part, Silver the 10 part, Iron the 8 part, Tinne the 7 part and a little more: wherefore in materiall and abſolute weight, Gold in reſpect of the water that it occupieth weigheth 18, and $\frac{1}{2}$ times heavier than the like quantitie of water, that is, as 18 $\frac{1}{2}$ to the Quickſilver 15 times, Lead 11 and $\frac{1}{2}$, Silver 10 and $\frac{1}{2}$, Copper 9 and $\frac{1}{10}$, Iron 8 and $\frac{1}{2}$, and Tinne 8 and $\frac{1}{2}$. Contrarily in reſpect of greatneſſe, if the water be as heavy as the Gold, then is the water almoſt 19 times greater than the magnitude of the Gold, and ſo may you judge of the reſt.

18. *How is it that a ballance having like weight in each ſcale, and hanging* in æquilibrio *in the aire, being placed in another place, (without removing any weight) it ſhall ceaſe to hang* in æquilibrio *ſenſibly: yea by a great difference of weight?*

THis is eaſie to be reſolved by conſidering different mettles, which though they weigh

weigh equall in the aire, yet in the water there will be an apparant difference; as suppose so that in the ſcale of each Ballance be placed 18 pound weight of ſeverall metalls, the one Gold, and the other Copper, which being *in æquilibrio* in the aire, placed in the water, will not hang ſo, becauſe that the Gold loſeth neare the 1/8 part of his weight, which is about 2 pound, and the Copper loſeth but his 1/9 part, which is 2 pound; wherefore the Gold in the water weigheth but 17 pound, and the Copper 16 pound, which is a difference moſt ſenſible to confirme that point.

9. To ſhew what waters are heavier one than another, and how much.

PHyſicians have an eſpeciall reſpect unto this, judging that water which is lighteſt is moſt healthfull and medicinall for the body, & Sea-men knowe that the heavieſt waters do beare moſt, and it is knowne which water is heavieſt thus. Take a piece of wax, and faſten Lead unto it, or ſome ſuch like thing that it may but preciſely ſwimme, for then it is equal to the like magnitude of water, then put it into another veſſell which hath contrary water, and if it ſinke, then is that water lighter than the other: but if it ſinke not ſo deep, then it argueth the water to be heavier or more groſſer than the firſt water, or one may take a piece of wood, and marke the quantitie of ſinking of it into ſeverall waters, by which you may judge

which

which is lighteſt or heavieſt, for in that which it ſinkes moſt, that is infallibly the lighteſt, and ſo contrarily.

20. *How to make a Pound of water weigh as much as 10, 20, 30, or a hundred pound of Lead; nay as much as a thouſand, or ten thouſand pound weight?*

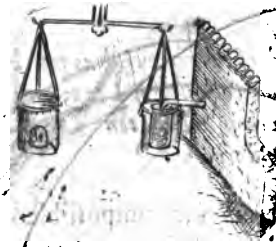
THis propoſition ſeems very impoſſible, yet water incloſed in a veſſell, being conſtrained to dilate it ſelfe, doth weigh ſo much as though there were in the concavitie of it a ſolid body of water.

There are many wayes to experiment this propoſition, but to verifie it, it may be ſufficient to produce two excellent ones onely: which had they not been really acted, little credit might have been given unto it.

The firſt way is thus: Take a Magnitude which takes up as much place as a hundred or a thouſand pound of water, and ſuppoſe that it were tied to ſome thing that it may hang in the aire; then make a Ballance that one of the ſcales may inviron it, yet ſo that it touch not the ſides of it: but leave ſpace enough for one pound of water: then having placed 100 pound weight in the other ſcale, throw in the water about the Magnitude, ſo that one pound of water ſhall weigh downe the hundred pound in the other Ballance.

The ſecond vvay is yet more admirable: take a common Ballance that is capable to receive

10



10 or 20 pound of water, then put into it a magnitude which may take up the place of 9 or 19 pound of water, which muſt be hung at ſome Iron or beame which is placed in a wall; ſo that it hang quiet: (now it is not materiall whether the magnitude be hollow or maſſie) ſo that it touch not the Ballance in which it is put, for then having put the Lead or weight into the other Ballance, poure in a pound of water into the Ballance where the magnitude is, and you ſhall ſee that this one pound of water ſhall counterpoiſe the 10 or 20 pound of Lead which is ſet in the other Ballance.

PROBLEM. LXXXVI.

Of ſundry Queſtions of Arithmetick, and firſt of the number of ſands.

IT may be ſaid incontinent, that to undertake this were impoſſible, either to number the Sands of *Lybia*, or the Sands of the Sea; and it vvas this that the Poets ſung, and that vvhich the vulgar beleeves; nay, that vvhich long ago certaine Philoſophers to *Gelon* King of *Sici-*

ly

ly reported, that the graines of ſand vvere innumerable: But I anſvvere vvith *Archimedes*, that not only one may number thoſe vvhich are at the border and about the Sea; but thoſe vvhich are able to fill the vvhole vvorld, if there vvere nothing elſe but ſand; and the graines of ſands admitted to be ſo ſmall, that 10 may make but one graine of *Poppy*: for at the end of the account there need not to expreſſe them, but this number 308409794 56, and 35 Ciphers at the end of it. *Clavius* and *Archimedes* make it ſomevvhat more, becauſe they make a greater firmament than *Tycho Brahe* doth; and if they augment the Vniverſe, it is eaſie for us to augment the number, and declare aſſuredly how many graines of ſand there are requiſite to fill another vvorld, in compariſon that our viſible vvorld vvere but as one graine of ſand, an atome or a point; for there is nothing to do but to multiply the number by it ſelfe, vvhich vvill amount to ninety places, vvhereof twentie are theſe, 951437981349109559 36, and 70 Ciphers at the end of it: vvhich amounts to a moſt prodigious number, and is eaſily ſupputated: for ſuppoſing that a graine of Poppy doth containe 10 graines of ſand, there is nothing but to compare that little bovvle of a graine of Poppy, vvith a bovvle of an inch or of a foot, & that to be compared vvith that of the earth, and then that of the earth vvith that o the firmament, and ſo of the reſt.

2. *Divers metalls being melted together in one body, to finde the mixture of them.*

THis was a notable invention of *Archimedes*, related by *Vitrivius* in his Architecture, where he reporteth that the Gold-ſmith which King *Hiero* imployed for the making of the Golden Crowne, which was to be dedicated to the gods, had ſtolen part of it, and mixed Silver in the place of it: the King ſuſpicious of the work propoſed it to *Archimedes*, if by Art he could diſcover without breaking of the Crowne, if there had been made mixture of any other metall with the Gold. The way which he found out was by bathing himſelfe, for as he entred into the veſſell of water, (in which he bathed himſelfe) ſo the water aſcended or flew out over it, and as he pulled out his body the water deſcended: from which he gathered that if a Bowle of pure Gold, Silver, or other metall were caſt into a veſſell of water, the water proportionally according to the thing caſt in would aſcend; and ſo by way of Arithmetick the queſtion lay open to be reſolved: who being ſo intenſively taken with the invention, leapes out of the Bath all naked, crying as a man tranſported, *I have found, I have found*, and ſo diſcovered it.

Now ſome ſay that he took two Maſſes, the one of pure Gold, and the other of pure Silver; each equall to the weight of the Crowne, and therefore unequall in magnitude or greatneſſe; and

and then knowing the ſeverall quantities of water which was anſwerable to the Crown, and the ſeverall Maſſes, he ſubtilly collected, that if the Crowne occupied more place within the water than the Maſſe of Gold did; it appeared that there was Silver or other metall melted with it. Now by the rule of poſition, ſuppoſe that each of the three Maſſes weighed 18 pound apiece, and that the Maſſe of Gold did occupie the place of one pound of water, that of Silver a pound and a halfe, and the Crown one pound and a quarter only: then thus he might operate: the Maſſe of Silver which weighed 18 pounds, caſt into the water, did caſt out halfe a pound of water more then the Maſſe of Gold, which weighed 18 pound, and the Crowne which weighed alſo 18 pound, being put into a veſſell full of water, threw out more water than the Maſſe of Gold by a quarter of a pound, (becauſe of mixt metall which was in it:) therefore by the rule of proportion, if halfe a pound of water (the exceſſe) be anſwerable to 18 pound of Silver, one quarter of a pound of exceſſe ſhall be anſwerable to 9 pound of Silver, and ſo much was mixed in the Crowne.

Some iudge the way to be more facill by weighing the Crowne firſt in the aire; then in the water; in the aire it weighed 18 pound, and if it were pure Gold, in the water it would weigh but 17 pound; if it were Copper it would weigh but 16 pound; but becauſe vve vvill ſuppoſe that Gold and Copper is mixed together, it vvill vveigh leſſe then 17 pound,

yet more than 16 pound, and that according to the proportion mixed: let it then be ſuppoſed that it vveighed in the vvater 16 pound and 3 quarters, then might one ſay by proportion, if the difference of one pound of loſſe, (vvhich is betvveen 16 and 17) be anſvverable to 18 pound, to vvhat ſhall one quarter of difference be anſvverable to, vvhich is betvveen 17 and 16 ¾, and it vvil be 4 pound and a halfe; and ſo much Copper vvas mixed vvith the Gold.

Many men have delivered ſundry vvayes to reſolve this propoſition ſince *Archimedes* invention, and it vvere tedious to relate the diverſities.

Baptiſta Benedictus amongſt his Arithmeticall 7 *heoremes*, delivers his vvay thus: if a Maſſe of Gold of equall bigneſſe to the Crovvne did vveigh 20 pound, and another of Silver at a capacity or bigneſſe at pleaſure, as ſuppoſe did vveigh 12 pound, the Crovvne or the mixt body would vveigh more than the Silver, and leſſer than the Gold, ſuppoſe it vveighed 16 pound vvhich is 4 pound leſſe than the Gold by 8 pound, then may one ſay, if 8 pound of difference come from 12 pound of Silver, from vvhence cómes 4 pound vvhich vvill be 6 pound and ſo much Silver vvas mixed in it, &c.

3. *Three*

3. Three men bought a quantitie of wine, each paid alike, and each was to have alike; it happened at the laſt partition that there were 21 Barrells, of which 7 were full, 7 halfe full, and 7 empty, how muſt they ſhare the wine and veſſells, that each have as many veſſells one as another, & as much wine one as another?

THis may be anſwered two wayes as followeth, and theſe numbers 2,2,3, or 3,3,1, may ſerve for direction, and ſignifies that the firſt perſon ought to have 3 Barrells full, and as many empty ones, and one which is halfe full; ſo he ſhall have 7 veſſells and 3 Barrels, and a halfe of liquor; and one of the other ſhall in like manner have as much, ſo there will remaine for the third man 1 Barrell full, 5 which are halfe full, and 1 empty, and ſo every one ſhall have alike both in veſſells and wine. And generally to anſwer ſuch queſtions, divide the number of veſſells by the number of perſons, and if the Quotient be not an intire number, the queſtion is impoſſible; but when it is an intire number, there muſt be made as many parts as there are 3 perſons, ſeeing that each part is leſſe than the halfe of the ſaid Quotient: as dividing 21 by 3 there comes 7 for the Quotient, which may be parted in theſe three parts, 2,2,3, or 3,3,1, each of which being leſſe than halfe of 7.

4. There is a Ladder which ſtands upright againſt a wall of 10 *foot high, the foot of it is pulled out* 6 *foot from the wall upon the pavement: how much hath the top of the Ladder deſcended?*

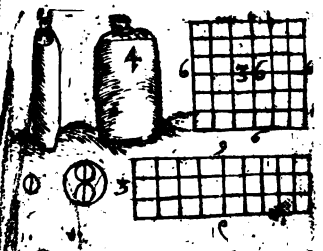
THe anſvver is, 2 foot: for by *Pythagoras* rule the ſquare of *D B*, the *Hypothenuſal* is equall to the ſquare of *D A* 6, & *A B* 10. Novv if *D A* be 6 foot, and *A B* 10 foot, the ſquares are 36 and 100, vvhich 36 taken from 100 reſts 64, vvhoſe Roote-quadrate is 8. ſo the foot of the Ladder being novv at *D*, the toppe vvill be at *C*, 2 foot lovver than it vvas vvhen it vvas at *B*.

PROBLEM. LXXXVII.

Witty ſuits or debates between Cains *and* Sempronius, *upon the forme of figures, which Geometricians call Iſoperimeter, or equall in circuit or compaſſe.*

MArvell not at it if I make the Mathematicks takeplace at the Barre, and if I ſet forth

forth here *Bartolus*, who witneſſeth of himſelfe, that being then an ancient Doctor in the Law, he himſelfe took upon him to learne the elements and principles of *Geometry*, by which he might ſet forth certaine Lawes touching the diviſions of Fields, Waters, Iſlands, and other incident places: now this ſhall be to ſhew in paſſing by, that theſe ſciences are profitable and behovefull for Judges, Counſellors, or ſuch, to explaine many things which fall out in Lawes, to avoid ambiguities, contentions, and ſuits often.



1. *Incident.*

Caius had a field which was directly ſquare, having 24 meaſures iu Circuit, that was 6 on each ſide: *Sempronius* deſiring to fit himſelfe, prayed *Caius* to change with him for a field which ſhould be equivalent unto his, and the bargaine being concluded, he gave him for counterchange a piece of ground which had juſt as much in circuit as his had, but it was not ſquare, yet *Quadrangular* and *Rectangled*, having 9 meaſures in length for each of the two longeſt ſides, and 3 in breadth for each ſhorter ſide: Now *Caius* which was not the moſt ſub-

tilleſt nor wiſeſt in the world accepted his bargaine at the firſt, but afterwards having conferred with a Land-meaſurer and Mathematician, found that he was over-reached in his bargaine, and that his field contained 36 ſquare meaſures, and the other field had but 27 meaſures, (a thing eaſie to be knowne by multiplying the length by the breadth:) *Sempronius* contested with him in ſuite of Law, and argued that figures which have equall *Perimeter* or *circuit*, are equall amongſt themſelves: my field, ſaith he, hath equall circuit with yours, therefore it is equall unto it in quantitie. Now this was ſufficient to delude a Judge which was ignorant in Geometricall proportions, but a Mathematician will eaſily declare the deceit, being aſſured that figures which are *Iſoperemiter*, or equall in circuit, have not alwayes equall capacitie or quantitie: ſeeing that with the ſame circuit, there may be infinite figures made which ſhall be more and more capable, by how much they have more Angles, equall ſides, and approach nearer unto a circle, (which is the moſt capableſt figure of all,) becauſe that all his parts are extended one from anothes, and from the middle or Centre as much as may be: ſo we ſee by an infallible rule of experience, that a ſquare is more capable of quantitie than a Triangle of the ſame circuit, and a *Pentagone* more than a ſquare, and ſo of others, ſo that they be regular figures that have their ſides equall,

otherwiſe

otherwiſe there might be that a regular Triangle, having 24 meaſures in circuit might have more capacitie than a rectangled *Parallelogram*, which had alſo 24 meaſures of circuit, as if it were 11 in length, and 1 inbreadth, the circuit is ſtill 24, yet the quantitie is but 11. and if it had 6 every way, it gives the ſame *Perimetur*, *viz.* 24. but a quantitie of 36 as before.

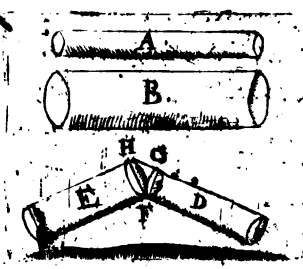
2. Incident.

Sempronius having borrowed of *Caius* a ſack of Corne, which was 6 foot high and 2 foot broad, and when there was queſtion made to repay it, *Sempronius* gave *Caius* back two ſacks full of Corne, which had each of them 6 foot high & 1 foot broad: who beleeved that if the ſacks were full he was repaid, and it ſeems to have an appearance of truth barely looked on. But it is moſt evident in demonſtration, that the 2 ſacks of Corn paid by *Sempronius* to *Caius*, is but halfe of that one ſack which he lent him: for a *Cylinder* or ſack having one foot of diameter, and 6 foot of length, is but the 4 part of another *Cylinder*, whoſe length is 6 foot, and his diameter is 2 foot: therefore two of the leſſer *Cylinders* or ſackes, is but halfe of the greater; and ſo *Caius* was deceived in halfe his Corne.

3. Incident.

SOme one from a common Fountaine of a City hath a Pipe of water of an inch diameter;

ter; to have it more commodious, he hath leave to take as much more water, whereupon he gives order that a Pipe be made of two inches diameter. Now you will say presently that it is reason to be so bigge, to have just twice as much water as he had before: but if the Magistrate of the Citie understood Geometricall proportions, he would soon cause it to be amended, & shew that he hath not only taken twice as much water as he had before, but foure times as much: for a Circular hole which is two inches diameter is foure times greater than that of one inch, and therefore will cast out four times as much water as that of one inch, and so the deceit is double also in this.



Moreover, if there were a heap of Corne of 20 foot every way, which was borrowed to be paid next yeare the party having his Corne in heapes of 12 foot every way, and of 10 foot every way, proffers him 4 heapes of the greater or 7 heaps of the lesser, for his owne heap of 20 every way, which was lent: here it seems that the proffer is faire, nay with advantage, yet the losse would be neare 1000 foot. Infinite of such causes do arise from Geometricall figures, which are able to deceive a Judge or

Magistrate

Magiſtrate, vvhich is not ſomevvhat ſeene in *Mathematicall Documents.*

PROBLEM. LXXXVIII.

Containing ſundry Queſtions in matter of Coſmography.

FIrſt, it may be demanded, vvhere is the middle of the vvorld? I ſpeak not here Mathematically, but as the vulgar people, vvho aſk, vvhere is the middle of the vvorld? in this ſence to ſpeak abſolutely there is no point vvhich may be ſaid to be the middle of the ſurface, for the middle of a Globe is every vvhere: notvvithſtanding the *Holy Scriptures* ſpeake reſpectively, and make mention of the middle of the earth, and the interpreters apply it to the Citie of *Jeruſalem* placed in the middle of *Paleſtina*, and the habitable vvorld, that in effect taking a mappe of the vvorld, and placing one foot of the Compaſſes upon *Jeruſalem*, and extending the other foot to the extremity of *Europe*, *Aſia*, and *Africa*, you ſhall ſee that the Citie of *Jeruſalem* is as a Centre to that Circle.

2. Secondly, how much is the depth of the earth, the height of the heavens, and the compaſſe of the world?

FRom the ſurface of the earth unto the Centre according to ancient traditions, is 3436. miles, ſo the vvhole thickneſſe is 6872 miles.

of which the whole compaſſe or circuit of the earth is 21600 miles.

From the Centre of the earth to the Moone there is neare 56 Semidiameters of the earth, which is about 192416 miles. unto the Sunne there is 1142 Semidiameters of the earth, that is in miles 3924912; from the ſtarry firmament to the Centre of the earth there is 14000 Semidiameters, that is, 48184000 miles, according to the opinion and obſervation of that learned *Tycho Brahe*.

From theſe meaſures one may collect by Arithmeticall ſupputations, many pleaſant propoſitions in this manner.

Firſt, if you imagine there were a hole through the earth, and that a Milſtone ſhould be let fall down into this hole, and to move a mile in each minute of time, it would be more than two dayes and a halfe before it would come to the Centre, and being there it would hang in the aire.

Secondly, if a man ſhould go every day 20 miles, it would be three yeares wanting but a fortnight, before he could go once about the earth; and if a Bird ſhould fly round about it in two dayes, then muſt the motion be 450 miles in an houre.

Thirdly, the Moone runnes a greater compaſſe each houre, than if in the ſame time ſhe ſhould runne twice the Circumference of the whole earth.

Fourthly, admit it be ſuppoſed that one ſhould

ſhould go 20 miles in aſcending towards the heavens every day, he ſhould be above 15 years before he could attaine to the Orbe of the Moone.

Fifthly, the Sunne makes a greater way in one day than the Moone doth in 20 dayes, becauſe that the Orbe of the Sunnes circumference is at the leaſt 20 times greater than the Orbe of the Moone.

Sixthly, if a Millſtone ſhould deſcend from the place of the Sunne a thouſand miles every houre, (which is above 15 miles in a minute, farre beyond the proportion of motion) it would be above 163 dayes before it would fall dovvne to the earth.

Seventhly, the Sunne in his proper ſphere moves more than ſeven thouſand five hundred and ſeventy miles in one minute of time: novv there is no Bullet of a Cannon, Arrovv, Thunderbolt, or tempeſt of vvinde that moves vvith ſuch quickneſſe.

Eightly, it is of a farre higher nature to conſider the exceeding and unmoveable quickneſſe of the ſtarry firmament, for a ſtarre being in the *Æquator*, (which is juſt between the Poles of the world) makes 125986 miles in one houre which is two hundred ſixe thouſand nine hundred and ſeventy foure miles in one minute of time: & if a Horſeman ſhould ride every day 40 miles, he could not ride ſuch a compaſſe in a thouſand yeares as the ſtarry firmament moves in one houre, which is more than if one

ſhould

ſhould move about the earth a thouſand times in one houre, and quicker than poſſible thought can be imagined: and if a ſtarre ſhould flye in the aire about the earth with ſuch a prodigious quickneſſe, it would burne and conſume all the world here below. Behold therefore how time paſſeth, and death haſteth on: this made *Copernicus*, not unadviſedly to attribute this motion of *Primum mobile* to the earth, and not to the ſtarry firmament; for it is beyond humane ſenſe to apprehend or conceive the rapture and violence of that motion being quicker than thought; and the word of God teſtifieth that the Lord made all things in *number, meaſure, weight*, and *time*.

PROBLEM. XCII.

To finde the Biſſextile yeare, the Dominicall letter, and the letters of the moneth.

LEt 123, or 124, or 125, or 26, or 27, (which is the remainder of 1500, or 1600) be divided by 4, which is the number of the Leape-yeare, and that which remaines of the diviſion, ſhewes the leap-yeare, as if one remaine, it ſhewes that it is the firſt yeare ſince the Biſſextile or Leap-year, if two, it is the ſecond yeare &c. and if nothing remaine, then it is the Biſſextile or Leap-yeare, and the Quotient ſhews you how many Biſſextiles or Leap-yeares there are conteined in ſo many yeares.

To

To finde the Circle of the Sun by the fingers.

LEt 123, 24, 25, 26, or 27, be divided by 28, (which is the Circle of the Sunne or whole revolution of the Dominicall letters) and that which remaines is the number of joynts, which is to be accounted upon the fingers by *Filius eſto Dei, cœlum bonus accipe, gratis*: and where the number ends, that finger it ſheweth the yeare which is preſent, and the words of the verſe ſhew the *Dominicall letter*.

Example.

DIvide 123 by 28 for the yeare (and ſo of other yeares) and the Quotient is 4, and there remaineth 11, for which you muſt account 11 words: *Filius eſto Dei, &c.* upon the joynts beginning from the firſt joynt of the *Index*, and you ſhall have the anſwer.

For the preſent to know the *Dominicall letter* for each moneth, account from *January* unto the moneth required, including *January*, and if there be 8, 9, 7, or 5, you muſt begin upon the end of the finger from the thumbe and account, *Adam degebat, &c.* as many words as there are moneths, for then one ſhall have the letter which begins the moneth; then to know what day of the moneth it is, ſee how many times 7 is comprehended in the number of dayes, and take the reſt, ſuppoſe 4, account upon the firſt finger within & without by the joynts,

unto

unto the number of 4, which ends at the end of the finger: from whence it may be inferred that the day required was Wednesday, Sunday being attributed to the first joynt of the first finger or Index: and so you have the present yeare, the Dominicall letter, the letter which begins the Moneth, and all the dayes of the Moneth.

PROBLEM. XCIII.

To finde the New and Full Moone in each Moneth.

ADde to the Epact for the yeare, the Moneth from March, then subtract that surplus from 30, and the rest is the day of the Moneth that it will be New Moone, and adding unto it 14, you shall have that Full Moone.

Note.

THat the Epact is made alwayes by adding 11 unto 30, and if it passe 30, subtract 30, and adde 11 to the remainder, and so *ad infinitum*: as if the Epact were 12, adde 11 to it makes 23 for the Epact next year, to which adde 11 makes 34, subtract 30, rests 4 the Epact for the yeare after, and 15 for the yeare following that, and 26 for the next, and 7 for the next, &c.

PROB-

PROBLEM. XCIV.

To finde the Latitude of a Countrey.

THoſe that dwell between the North-Poſe and the *Tropicke* of *Cancer*, have their Spring and Summer between the 10 of *March*, and the 13 of *September*: and therefore in any day between that time, get the ſunnes diſtance by inſtrumentall obſervation from the zenith at noone, and adde the declination of the ſun for that day to it: ſo the Aggragate ſheweth ſuch is the Latitude, or Poles height of that Countrey. Now the declination of the ſunne for any day is found out by Tables calculated to that end: or Mechanically by the Globe, or by Inſtrument it may be indifferently had: and here note that if the day be between the 13 of *September* and the 10 of *March*, then the ſunnes declination for that day muſt be taken out of the diſtance of the ſunne from the zenith at noone: ſo ſhall you have the Latitude, as before.

PROBLEM XCV.

Of the Climates of countreys, and to finde in what Climate any countrey is under.

CLimates as they are taken Geographically ſignifie nothing elſe but when the length

of the longeſt day of any place, is half an houre longer, or ſhorter than it is in another place (and ſo of the ſhorteſt day) and this account to begin from the Equinoctiall Circle, ſeeing all Countreys under it have the ſhorteſt and longeſt day that can be but 12 houres; But all other Countreys that are from the Equinoctiall Circle either towards the North or South of it unto the Poles themſelves, are ſaid to be in ſome one Climate or other, from the Equinoctiall to either of the Poles Circles, (which are in the Latitude of 66 degr. 30 m.) between each of which Polar Circles and the Equinoctial Circle there is accounted 24 Climates, which differ one from another by halfe an hours time: then from each Polar Circle, to each Pole there are reckoned 6. other Climates which differ one from another by a moneths time: ſo the whole earth is divided into 60 Climates, 30 being allotted to the Northerne Hemiſphere, and 30 to the Southerne Hemiſpheare. And here note, that though theſe Climats which are betweene the Equinoctiall and the Polar Circles are equall one unto the other in reſpect of time, to wit, by halfe an houre; yet the Latitude, breadth, or internall, conteined between Climate and Climate, is not equall: and by how much any Climate is farther from the Equinoctiall than another Climate, by ſo much the leſſer is the intervall between that Climate and the next: ſo thoſe that are neareſt the Equinoctial are larg-

eſt

eſt, and thoſe which are fartheſt off moſt contracted: and to finde what Climate any Countrey is under: ſubtract the length of an Equinoctiall day, to wit, 12 houres from the length of the longeſt day of that Countrey; the remainder being doubled ſhews the Climate: So at *London* the longeſt day is neare 16 houres and a halfe; 12 taken from it there remaines 4 houres and a halfe, which doubled makes 9 halfe houres, that is, 9 Climates; ſo *London* is in the 9 climate.

PROBLEM. XCVI.

Of Longitude and Latitude of the Earth and of the Starres.

Longitude of a Countrey, or place, is an arcke of the *Æquator* conteined between the Meridian of the Azores, and the Meridian of the place, and the greateſt Longitude that can be is 360 degrees.

Note.

That the firſt Meridian may be taken at pleaſure upon the Terreſtriall Globe or Mappe, for that ſome of the ancient Aſtronomers would have it at *Herculos* Pillars, which is at the ſtraights at *Gibraltar*: *Ptolomy* placed it at the *Canary Iſlands*, but now in theſe latter times it is held to be neare the *Azores*. But why it was firſt placed by *Ptolomy* at the *Canary Iſlands*, were becauſe that in his time theſe Iſlands were the fartheſt weſterne parts of the world that vvas then diſcovered. And vvhy it reteines his place novv at Saint *Michaels* neare the

Azores, is that becauſe of many accurate obſervations made of late by many expert Navigators and Mathematicians, they have found the Needle there to have no variation, but to point North and South: that, is to each Pole of the world: and why the Longitude from thence is accounted Eaſtwards, is from the motion of the Sunne Eaſtward, or that *Ptolomy* and others did hold it more convenient to begin from the Weſterne part of the world and ſo account the Longitude Eaſtward from Countrey to Countrey that was then knowne; till they came to the Eaſterne part of *Aſia*, rather than to make a beginning upon that which was unknowne: and having made up their account of reckoning the Longitude from the Weſterne part to the Eaſtern part of the world knowne, they ſuppoſed the reſt to be all ſea, which ſince their deaths hath been found almoſt to be another habitable world.

To finde the Longitude of a Countrey.

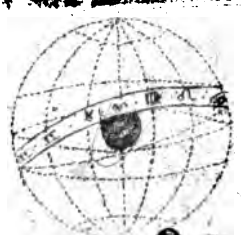
IF it be upon the Globe, bring the Countrey to the Braſen Meridian, and whatſoever degree that Meridian cuts in the Equinoctiall, that degree is the Longitude of that Place: if it be in a Mappe, then mark what Meridian paſſeth over it, ſo have you the Longitude thereof, if no Meridian paſſe over it, then take a paire of Compaſſes, and meaſure the diſtance betweene the Place and the next Meridian, and apply it

to

to the divided parallel or *Æquator*, ſo have you the Longitude required.

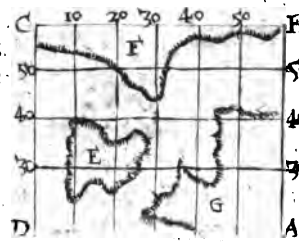
Of the Latitude of Countreys.

LAtitude of a Countrey is the diſtance of a Countrey from the Equinoctiall, or it is an Arke of the Meridian conteined betweene the Zenith of the place and the *Æquator*; which is two-fold, *viz.* either North-Latitude or South-Latitude, either of which extendeth from the Equinoctiall to either Pole, ſo the greateſt Latitude that can be is but 90. degrees: If any Northern Countrey have the Artick Circle verticall, which is in the Latitude of 66. gr. 30. m. the Sun will touch the Horizon in the North part thereof, and the longeſt day will be there then 24. houres, if the Countrey have leſſe Latitude than 66. degrees 30. m. the Sun will riſe and ſet, but if it have more Latitude than 66. gr. 30 m. it will be viſible for many dayes, and if the Countrey be under the Pole, the Sun will make a Circular motion above the Earth, and be viſible for a half yeare: ſo under the Pole there will be but one day, and one night in the whole yeare.



To finde the latitude of Countreys.

IF it be upon a Globe, bring the place to the Braſen Meridian, and the number of degrees which it meeteth therewith, is the Latitude of the place. Or with a paire of Compaſſes take the diſtance between the Countrey and the Equinoctiall, which applied unto the Equinoctiall will ſhew the Latitude of that Countrey; which is equall to the Poles height; if it be upon a Mappe. Then mark what parallel paſſeth over the Countrey and where it croſſeth the Meridian, that ſhall be the Latitude: but if no parallel paſſeth over it, then take the diſtance betweene the place and the next parallel, which applied to the divided Meridian from that parallel will ſhew the Latitude of that place.



To finde the diſtance of places.

IF it be upon a Globe: then with a paire of *Compaſſes* take the diſtance betweene the two Places, and apply it to the divided Meridian or *Æquator*, and the number of degrees ſhall ſhewe the diſtance; each degree being 60. miles. If it be in a Mappe (according to *Wrights* projection)

ection) take the distance with a paire of *Compasses* between the two places, and apply this distance to the divided Meridian on the Mappe right against the two places; so as many degrees as is conteined between the feet of the *Compasses* so much is the distance between the two places: If the distance of two places be required in a particular Map then with the *Compasses* take the distance between the two places, and apply it to the scale of Miles, so have you the distance, if the scale be too short, take the scale between the *Compasses*, and apply that to the two places as often as you can, so have you the distance requited.

Of the Longitude, Latitude, Declination, and distance of the Starres.

THe Declination of a starre is the neareſt distance of a Star from the *Æquator*; the Latitude of a Starre is the neareſt distance of a Sarre from the *Ecliptick*: the Longitude of a Starre is an Ark of the *Ecliptick* conteined between the beginning of *Aries*, and the Circle of the Starres Latitude, which is a circle drawne from the Pole of the *Ecliptick* unto the starre, and so to the *Ecliptick*. The distance between two Sarres in Heaven is taken by a *Crosse-staffe* or other Instrument, and upon a Globe it is done by taking between the feet of the *Compasses* the two Starres, and applying it

to the *Æquator*, ſo have you the diſtance betweene thoſe two ſtarres.

How is it that two Horſes or other creatures being foaled or brought forth into the world at one and the ſame time, that after certaine dayes travell the one lived more dayes than the other, notwithſtanding they dyed together in one and the ſame moment alſo?

THis is eaſie to be anſwered: let one of them travell toward the Weſt and the other towards the Eaſt: then that which goes towards the Weſt followeth the Sunne: and therefore ſhall haye the day ſomewhat longer than if there had been no travell made, and that which goes Eaſt by going againſt the Sunne, ſhall have the day ſhorter, and ſo in reſpect of travell though they dye at one and the ſelfe ſame houre and moment of time, the one ſhall be older than the other.

From which conſideration may be inferred that a Chriſtian, a Jew, and a Saracen, may have their Sabbaths all upon one and the ſame day though notwithſtanding the Saracen holds his Sabath upon the Friday, the Jew upon the Saturday, and the Chriſtian upon the Sunday: For being all three reſident in one place, if the Saracen and the Chriſtian begin their travell upon the Saturday, the Chriſtian going Weſt, and the Saracen Eaſtwards, ſhall compaſſe the

Globe

Globe of the earth, thus the Christian at the concluſion ſhall gaine a day, and the Saracen ſhall loſe a day, and ſo meet with the Jew every one upon his owne Sabbath.

Certaine fine obſervations.

1 UNder the Equinoctiall the Needle hangs *in æquilibrio*, but in theſe parts it inclines under the Horizon, and being under the Pole it is thought it will hang verticall.

2 In theſe Countreys which are without the Tropicall Circles, the Sunne comes Eaſt and Weſt every day for a halfe yeare, but being under the Equinoctiall the Sun is never Eaſt, nor Weſt but twice in the yeare, to wit, the 10. of *March* and the 13 of September.

3 If a ſhip be in the Latitude of 23 gr. 30 m. that is, if it have either of the Tropicks verticall: then at what time the Sunnes Altitude is equall to his diſtance from any of the Equinoctiall points, then the Sunne is due Eaſt or Weſt.

4 If a ſhip be betweene the Equinoctiall and either of the Tropicks, the Sunne will come twice to one point of the compaſſe in the forenoone, that is, in one and the ſame poſition.

5 Vnder the Equinoctiall neare *Guinea* there is but two ſorts of windes all the year, 6 moneths a Northerly winde, and 6 moneths a Southerly winde, and the flux of the Sea is accordingly.

6 If two ſhips under the *Equinoctiall* be 100. leagues aſunder, and ſhould ſayle Northerly untill

untill they were come under the Artieke circle, they ſhould then be but 50 leagues aſunder.

7 Thoſe which have the Artick circle, verticall: when the Sunne is in the Tropick of *Cancer*, the Sun ſetteth not, but toucheth the weſtern part of the Horizon.

8 If the complement of the Sunnes height at noon be found equall to the Sunnes Declination for that day, then the *Equinoctiall* is verticall: or a ſhippe making ſuch an obſervation, the *Equinoctiall* is in the *Zenith*, or direct over them, by which Navigators know when they croſſe the line, in their travels to the Indies, or other parts.

9 The Sunne being in the *Equinoctiall*, the extremity of the ſtile in any Sunne-dyall upon a plaine, maketh a right line, otherwiſe it is *Elliptical*, *Hyperbolicall*, *&c.*

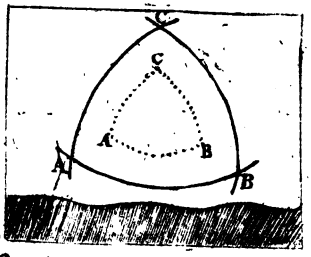
10 When the ſhadow of a man, or other thing upon a *Horizontall* plaine is equall unto it in length, then is the *Sunne* in the middle point between the Horizon and the *Zenith*, that is, 45 degrees high.

PROBLEM. XCVII.

To make a Triangle that ſhall have three right Angles.

OPen the *Compaſſes* at pleaſure: and upon *A*, deſcribe an Arke *B C*. then at the ſame opening, place one of the feet in *B*, and deſcribe the

the Ark *A C*. Lastly, place one of the feet of the *Compasses* in *C*. and describe the Arke *A B*. so shall you have the spherical *Æquilaterall Triangle A B C*, right angled at *A*, at *B*, and at *C*. that is, each angle comprehended 90. degrees: which can never be in any plaine Triangle, whether it be *Equilaterall, Isoceles, Scaleve, Orthogonall*, or *Opigonall*.



PROBLEM. XCVIII.

To divide a line in as many equall parts as one will, without compasses, or without seeing of it.

THis Propositon hath a fallacie in it, & cannot be practised but upon a *Maincordion*: for the Mathematicall line which proceeds from the flux of a point, cannot be divided in that wise: One may have therefore an Instrument which is called *Maincordion*, because there is but one cord: and if you desire to divide your line into 3 parts, run your finger upon the frets untill you found a third in musick: if you would have the fourth part of the line, then

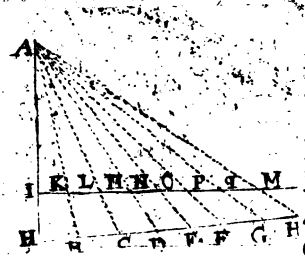
then finde the fourth found, a fifth, &c. ſo ſhall you have the anſwer.

PROBLEM. XCIX.

To draw a line which ſhall incline to another line, yet never meet; againſt the Axiome of Parallels.

THis is done by help of a Conoeide line, produced by a right line upon one & the ſame plaine, held in great account amongſt the Ancients, and it is drawne after this manner.

Draw a right line infinitely, and upon ſome end of it, as at *I*, draw a perpendicular line *I A*. augment it to *H*. then from *A*. draw lines at pleaſure to interſect the line *I M*. in each of which lines from the right line, *I M*. tranſferre *I H*. *viz*. *K B*. *L C*. *O D*. *P E*. *Q F*. *M G*. then from thoſe points draw the line *H B C D E F G*. which will not meet with the line *I M*. and yet incline nearer and nearer unto it.

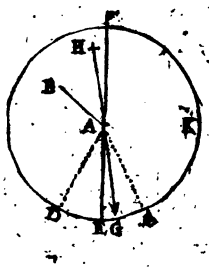


FROM

PROBLEM. C.

To observe the variation of the compasses, or needle in any places.

FIrst describe a Circle upon a plaine, so that the Sun may shine on it both before noone and afternoone: in the centre of which Circle place a *Gnemon* or *wire* perpendicular as *A B*, and an houre before noone marke the extremitie of the shadow of *A B*, which suppose it be at *C*. describe a Circle at that semidiameter *C D F*. then after noone mark when the top of the shadow of *A B*, toucheth the Circle, which admit in *D*; divide the distance *C D* into two equall parts, which suppose at *E*. draw the line *E A F*. which is the Meridian line, or line of *North & South*: now if the Arke of the Circle *C D* be divided into degrees. place a Needle *G H*, upon a plaine set up in the Centre, and marke how many degrees the point of the Needle *G*, is from *E*. so much doth the Needle vary from the North in that place.

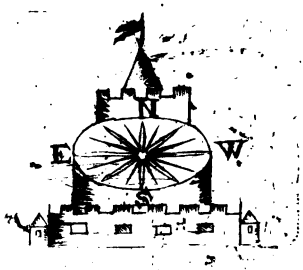


PROB.

PROBLEM. CI.

How to finde at any time which way the wind is in ones Chamber, without going abroad?

VPon the Plancking or floore of a Chamber, Parlor, or Hall, that you intend to have this device, let there come downe from the top of the house a hollow post, in which place an Iron rod that it ascend above the house 10, or 6 foot with a vane or a scouchen at it to shew the winds without: and at the lower end of this rod of Iron, place a Dart which may by the moving of the vane with the wind without, turne this Dart which is within: about which upon the plaister must be described a Circle divided into the 32 points of the Mariners Compasse pointed and distinguished to that end, then may it be marked by placi to Compasse by it; for having noted the North point, the East, &c. it is easie to note all the rest of the points: and so at any time comming into this Roome, you have nothing to do but to look up to the Dart, which will point you out what way the winde bloweth at that instant.



PROB.

PROBLEM. CII.

How to draw a parallel ſpherical line with great eaſe?

FIrſt draw an obſcure line *G F.* in the middle of it make two points *A B*, (which ſerves for Centres, then place one foot of the Compaſſes in *B*, and extend the other foot to *A*, and deſcribe the *ſemicircle A C.* then place one foot of the Compaſſes in *A*, and extend the other foot to *C*, and deſcribe the *ſemicircle C D.* Now place the Compaſſes in *B*, and extend the other foot unto *D*, and deſcribe the *ſemicircle D E*, and ſo *ad infinitum*; which being done neatly, that there be no right line ſeene nor where the Compaſſes were placed, will ſeeme very ſtrange how poſſibly it could be drawne with ſuch exactnes, to ſuch which are ignorant of that way.

PRO.

PROBLEM: CIII.

To measure an inaccessible distance, as the breadth of a River with the help of ones hat onely.

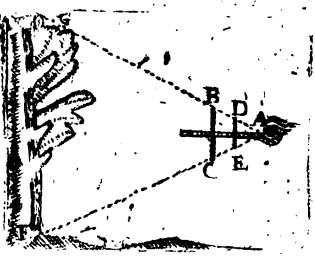
THe way of this is easie: for having ones hat upon his head, come neare to the bank of the River, and holding your head upright (which may be by putting a small stick to some one of your buttons to prop up the chin) pluck downe the brim or edge of your hat untill you may but see the other side of the water, then turne about the body in the same posture that it was before towards some plaine, and marke where the sight by the brimme of the hat glanceth on the ground; for the distance from that place to your standing, is the breadth of the River required.

PROBLEM. CIIII.

How to measure a height with two strawes or two small stickes.

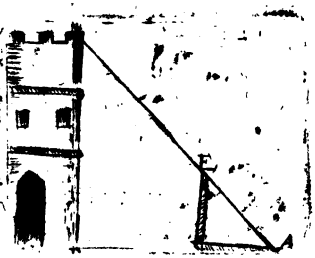
TAke two strawes or two stickes which are one as long as another, and place them at right Angles one to the other, as *A B.* and *AC.* then holding *AB.* parallel to the ground, place the end *A* to the eye at *A.* and looking to the other top *B C.* at *C.* by going backward or forward

ward untill you may ſee the top of the Tower or tree, which ſuppoſe at *E*. So the diſtance from your ſtanding to the Tower or Tree, is equall to the height thereof above the levell of the eye: to which if you adde your owne height you have the whole height.



Otherwiſe.

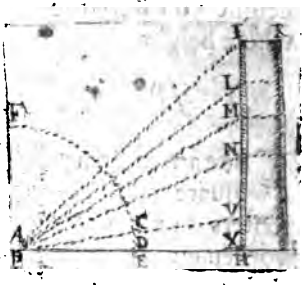
TAke an ordinary ſquare wch Carpenters or other workemen uſe, as *H K L*. and placing *H*. to the eye ſo that *H K*. be levell, go back or come nearer untill that by it you may ſee the top *M*. for then the diſtance from you to the height is equall to the height.



PROBLEM. CV.

How to make ſtatues, letters, howles, or other things which are placed in the ſide of a high building, to be ſeen below of an equall bigneſſe.

LEt *B C.* be a Pillar 7 yards high, and let it be required that three yards above the levell of the eye *A*, *viz.* at *B.* be placed a Globe, and 9 yards above *B.* be placed another, & 22. yards above that be placed another Globe: how much ſhall the Diameter of theſe Globes be, that at the eye, at *A*, they may all appeare to be of one and the ſame Magnitude: It is thus done, firſt draw a line as *A K.* and upon *K.* erect a perpendicular *K X.* divide this line into 27 parts, and according to *A K.* deſcribe an Arke *K Y.* then from *K* in the perpendicular *K X*, account 3. parts, *viz.* at *L*, which ſhall repreſent the former three yardes, and draw the line *L A.* from *L*, in the ſaid perpendicular reckon the diameter of the leſſer Globe of what Magnitude it is intended to be: ſuppoſe *S L*, and draw the line *S A.* cutting the Arke *V K.* in *N.* then from *K* in the perpendicular account 9 yards, which admit at *T.* draw *T A*, cutting *Y K.* in *O* transferre the Arke *M N*, from



A

A to *P*. and draw *A P*. which will cut the perpendicular in *V*. so a line drawne from the middle of *V F*. unto the visuall lines *A I*, and *A V*, shall be the diameter of the next Globe: Lastly, account from *K*. in the perpendicular *X K*. 22 parts, and draw the line *W A*. cutting *Y K* in *Q*. then take the Arke *M N*, and transferre it from *Q* to *R* and draw *A R*, which will cut the perpendicular in *X*. so the line which passeth by the meddle of *X W*. perpendicular to the visuall line *A W*, and *A X*. be the Diameter of the third Globe, to wit 5, 6. which measures transferred in the Pillar *B C*. which sheweth the true Magnitude of the Globes 1, 2, 3. from this an Architector doth proportion his Images, & the foulding of the Robes which are most deformed at the eye below in the making, yet most perfect when it is set in his true height above the eye.

PROBLEM. CVI.

How to disguise or disfigure an Image, as a head, an arme, a whole body, &c. so that it hath no proportion, the eares to become long: the nose as that of a swan, the mouth as a coaches entrance, &c. yet the eye placed at a certaine point will be seen in a direct & exact proportion.

I Will not strive to set a Geometricall figure here, for feare it may seeme too difficult to understand,

derſtand, but I will indeavour by diſcourſe how Mechanically with a Candle you may perceive it ſenſible: firſt there muſt be made a figure upon Paper, ſuch as you pleaſe, according to his juſt proportion, and paint it as a Picture (which painters know well enough to do) afterwards put a Candle upon the Table, and interpoſe this figure obliquely, between the ſaid Candle and the Bookes of Paper, where you deſire to have the figure diſguiſed in ſuch ſort that the height paſſe athwart the hole of the Picture: then will it carry all the forme of the Picture upon the Paper, but with deformity; follow theſe tracts and marke out the light with a Coles black head or Ink: and you have your deſire.

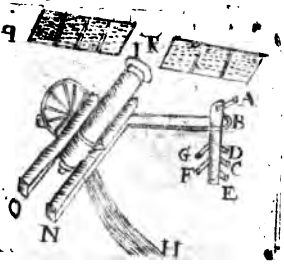
To finde now the point where the eye muſt ſee it in his naturall forme: it is accuſtomed according to the order of Perſpective, to place this point in the line drawne in height, equall to the largeneſſe of the narroweſt ſide of the deformed ſquare, and it is by this way that it is performed.

PROBLEM. CVII.

How a Cannon after that it hath ſhot, may be covered from the battery of the enemy.

LEt the mouth of a Cannon be *I*, the Cannon *M*. his charge *N O*, the wheele *L*, the axletree *P B*. upon which the Cannon is placed, at which

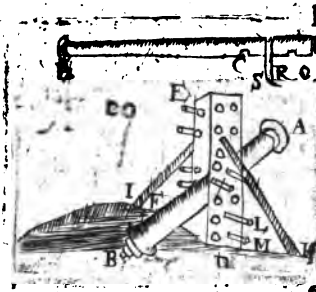
which end towards *B*, is placed a pillar *A &c.* supported with props *D*, *C*, *E*, *F*, *G*. about which the Axeltree turneth: now the *Cannon* being to shoot, it retires to *H*, which cannot be directly because of the Axletree, but it make a segment of a circle, and hides himselfe behind the wal *Q R*, and so preserves it selfe from the Enemies battery, by which meanes one may avoid many inconveniences which might arise: and moreover, one man may more easily replace it againe for another shot by help of poles tyed to the wall, or other help which may multiply the strength.



Problem: CVIII.

How to make a Lever, by which one man may alone place a Cannon upon his carriage, or raise what other weight he would.

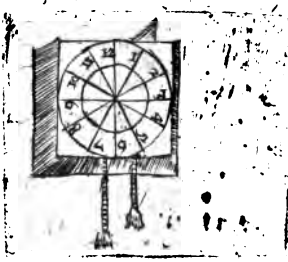
First place two thick boards upright, as the figure sheweth, pierced with holes, alike opposite one unto another as *C D*, and *E F*: & let *L*, and *M*, be the two barres of Iron which passeth through the holes *G H*, and *F*, *K*, the



two ſupports, or props, *A B*. the Cannon, *O P*, the Lever, *R S*, the two notches in the Lever, and *Q*, the hooke where the burthen or Cannon is tyed to. The reſt of the operation is ſo facill, that the youngeſt ſchollers or learners cannot faile to performe it: to teach *Minerva* were in vaine, and it were to Mathematicians injury in the ſucceeding Ages.

PROBLEM. CIX.

How to make a Clock with one onely wheele.



MAke the body of an ordinary Dyall, and divide the houre in the Circle into 12. parts: make a great wheele in height above the Axletree, to the which you ſhall place the cord of your counterpoize, ſo that it may deſcend, that in 12 houres

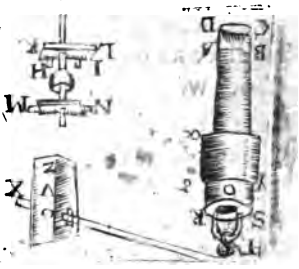
houres of time your *Index* or *Needle* may make one revolution, which may be knowne by a watch which you may have by you: then put a balance which may ſtop the courſe of the Wheele, and give it a regular motion, and you ſhall ſee an effect as juſt from this as from a Clock with many wheeles.

PROBLEM. CX.

How by help of two wheeles to make a Childe to draw up alone a hogſhead of water at a time: and being drawne up ſhall caſt out it ſelfe into another veſſell as one would have it.

LEt *R* be the *Pit* from whence water is to be drawne, *P* the hook to throw out the water when it is brought up (this hook muſt be moveable) let *A B* be the Axis of the wheele *S F*, which wheele hath divers forkes of Iron made at *G*, equally faſtened at the wheele; let *I*, be a Card, which is drawne by *K*, to make the wheele *S*, to turne, vvhich vvheele *S*, beares proportion to the vvheele *T*, as 8 to 2. let *N* be a Chaine of Iron to vvhich is tyed the veſſel *O*, and the other vvhich is in the Pit: *E F* is a piece of vvood vvhich hath a mortes in 1, and 2, by vvhich the Cord *I*, paſſeth, tyed at the vvall, as *K H*, and the other piece of timber of the little vvheele as *M*, mortiſed in likevviſe for the

ſhaine to paſſe through: draw the *Cord I*, by *K*, and the wheele will turne, & ſo conſequently the wheele *T*, which will cauſe the veſſell *Q* to raiſe; which being empty, draw the cord againe by *Y*, and the other veſſell which is in the pit will come out by the ſame reaſon. This is an invention which will ſave labour if practiſed; but here is to be noted that the pit muſt be large enough, to the end that it conteine two great veſſels to paſſe up and downe one by another.

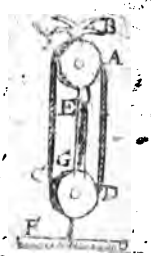


PROBLEM. CXI.

To make a Ladder of Cords, which may be carryed in ones pocket: by which one may eaſily mount up a Wall, or Tree alone.

TAke two Pullies *A*, & *D*, unto that of *A*, let there be faſtened a *Cramp* of Iron as *B*; and at *D*, let there be faſtened a ſtaffe of a foot and a halfe long as *F*, then the Pully *A*: place a hand of Iron, as *E*, to vvhich tie a cord of an halfe inch thick (vvhich may be of ſilk becauſe it is for the pocket:) then ſtrive to make faſt the Pully

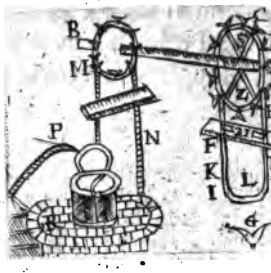
Pully *A*, by the help of the *Crampe* of Iron *B*, to the place that you intend to ſcale; and the ſtaffe *F*, being tyed at the Pully *D*, put it betvveen your legges as though you vvould ſit upon it: then holding the *Cord C* in your hand, you may guide your ſelfe to the place required; vvhich may be made more facill by the multiplying of Pullies. This ſecret is moſt excellent in Warre, and for lovers, its ſupportableneſſe avoids ſuſpition.



Problem. CXII.

How to make a Pumpe whoſe ſtrength is marvelous by reaſon of the great weight of water that it is able to bring up at once, and ſo by continuance.

LEt α ς γ δ, be the height of the caſe about two or three foot high, and broader according to diſcretion: the reſt of the *Caſe* or concavity let be *O*: let the ſucker of the Pumpe vvhich is made, be juſt for the *Caſe* or *Pumpes* head α ς γ δ, & may be made of vvood or braſſe of 4 inches thick, having a hole at *E*, vvhich deſcending



ſcending raiſeth up the cover P, by which iſſueth forth the water, & aſcending or raiſing up it ſhuts it or makes it cloſe: *R S*, is the handle of the ſucker tyed to the handle *T X*, which works in the poſt *V Z*. Let *A*, *B*, *C*, *D*, be a piece of Braſſe, *G* the piece which enters into the hole to *F*, to keep out the Aire. *H*, *I*, *K*, *L*, the piece tyed at the funnell or pipe: in which playes the Iron rod or axis *G*, ſo that it paſſe through the other piece *M N*, which is tyed with the end of the pipe of Braſſe.

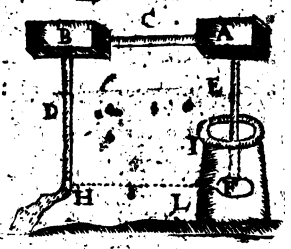
Note, that the lower end of the Ciſterne ought to be reſted upon a Gridiron or Iron Grate, which may be tyed in the pit, by which means lifting up and putting downe the handle, you may draw ten times more water than otherwiſe you could.

PROBLEM. CXIII.

How by meanes of a Ciſterne, to make water of a Pit continually to aſcend without ſtrength, or the aſſiſtance of any other Pumpe.

LEt *I L*, be the Pit where one would cauſe water to aſcend continually to: ach office of

of a houſe or the places which are ſeparated from it: let there be made a receiver as *A*, well cloſed up with lead or other matter that aire enter not in, to which faſten a pipe of lead as at *E*, which may have vent at pleaſure, then let there be made a Ciſterne as *B*, which may be communicative to *A*, by helpe of the pipe *G*, from which Ciſtern *B*, may iſſue the water of pipe *D*, which may deſcend to *H*, which is a little below the level of the water of the pit as much as is *G H*. to the end of which ſhall be ſoldered cloſe a Cock which ſhall caſt out the water by *K H*. Now to make uſe of it, let *B* be filled full of water, and when you would have it run turne the Cock, for then the water in *B*, will deſcend by *K*. and for feare that there ſhould be vacuity, nature which abhors it, will labour to furniſh and ſupply that emptineſſe out of the ſpring *F*, and that the *Pit* dry not, the Pipe ought to be ſmall of an indifferent capacity according to the greatneſſe or ſmalneſſe of the ſpring.

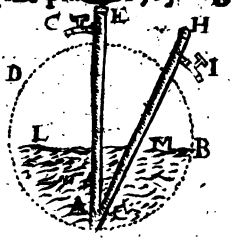


PROB.

Problem. CXIIII.

How out of a fountaine to caſt the water very high: different from a Probleme formerly delivered.

LEt the fountaine be *B D*, of a round forme (ſeeing it is the moſt capable and moſt perfect figure) place into it two pipes conjoyned as *E A*, and *H C*, ſo that no Aire may enter in at the place of joyning: let each of the Pipes have a cock *G*, & *L*: the cocke at *G*, being cloſed, open that at *I*, & ſo with a ſquirt force the water through the hole at *H*, then cloſe the Cocke at *A*, & draw out the ſquirt, and open the cock at *G*.



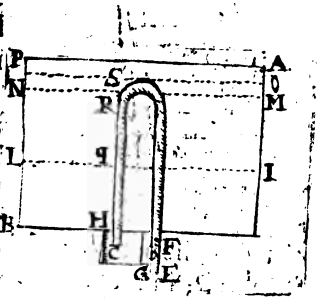
the Aire being before rarified will extend his dimentions, and force the water with ſuch violence, that it will amount above the height of one or two Pipes: and ſo much the more by how much the Machine is great: this violence will laſt but a little while if the Pipe have too great an opening, for as the Aire approacheth to his naturall place, ſo the force will diminiſh.

Prob.

PROBLEM. CXV.

How to empty the water of a Cisterne by a Pipe which shall have a motion of it selfe.

LEt *A B*, be the vessell; *C D E*, the Pipe: *H G*, a little vessell under the greater, in which one end of the Pipe is, *viz.* *C*, and let the other end of the Pipe *E*. passing through the bottome of the vessell at *F*, then as the vessell filleth so will the Pipe, and when the vessell, shall be full as farre as *P O*, the Pipe will begin to runne at *E*, of his owne accord, and never cease untill the vessell be wholly empty.

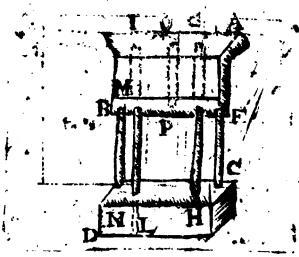


PROBLEM CXVI.

How to squirt or spout out a great height, so that one pot of water shall last a long time.

LEt there be prepared two vessels of Brasse, Lead, or of other matter of equal substance as are the two vessels *A B*, and *B D*, & let them be joyned together by the two Pillars *M N*, & *E F*: then let there be a pipe *H G*. which may passe through the cover of the vessel *C D*, and passe through *A B*, into *G*, making a little bunch or rising in the cover of the vessell *A B*, so that the pipe touch it not at the bottome:

then let there be ſolde̅red faſt another Pipe *I L*, which may be ſeparated from the bottome of the veſſell, and may have his bunchie ſwelling as the former without touching the bottome: as is repreſented in *L*, and paſſing through the bottome of *A B*, may be continued unto *I*, that is to ſay, to make an opening to the cover of the veſſell *A B*, & let it have a little mouth as a Trumpet: to that end to receive the water. Then there muſt further be added a very ſmal Pipe which may paſſe through the bottome of the veſſell *A B*, as let it be *O P*, and let there be a bunch; or ſwelling over it as at *P*, ſo that it touch not alſo the bottome: let there be further made to this leſſer veſſell an edge in forme of a Baſin to receive the water, which being done poure water into the Pipe *I L*, untill the veſſell *C D*, be full, then turne the whole Machine upſide downe: that the veſſell *C D*, may be uppermoſt, and *A B*, undermoſt: ſo by helpe of the pipe *G H*, the water of the veſſell *C D*, will runne into the veſſel *A B*, to have paſſage by the pipe *P O*. This motion is pleaſant at a feaſt in filling the ſaid veſſel with wine, which will ſpout it out as though it were from a boyling fountaine, in the forme of a threed very pleaſant to behold.



PROB.

PROBLEM. CXVIII.

How to practiſe excellently the reanimation of ſimples, in caſe the plants may not be tranſported to be replanted by reaſon of diſtance of places.

TAk ewhat ſimple you pleaſe, burne it and take the aſhes of it, and let it be calcinated two houres between two Creuſets wel luted, and extract the ſalt: that is, to put water into it in moving of it; then ſet it ſettle: and do it two or three times, afterwards evaporate it, that is, let the water be boyled in ſome veſſel, untill it be all conſumed: then there will remaine a ſalt at the bottome, which you ſhall afterwards ſowe in good Ground wel prepared: ſuch as the Theatre of husbandry ſheweth, and you ſhall have your deſire.

PROBLEM. CVIII.

How to make an infalliable perpetuall motion.

MIxe 5. or 6. ounces of ☿ with is equall weight of ♄, grinde it together with 10. or 12 ounces of ſublimate diſſolved in a celler upon a Marble the ſpace of foure dayes, and it will become like Oile, Olive, which diſtill with fire of chaffe or driving fire, and it will ſublime

ſubſime dry ſubſtance, then put water upon the earth (in forme of Lye) which will be at the bottom of the Limbeck, and diſſolve that which you can; filter it, then diſtill it, and there will be produced very ſubtill Antomes, which put into a bottle cloſe ſtopped, and keep it dry, and you ſhall have your deſire; with aſtoniſhment to all the world, and eſpecially to thoſe which have travelled herein without fruit.

PROBLEM. CXIX.

Of the admirable invention of making the Philoſophers Tree, which one may ſee with his eye to grow by little and little.

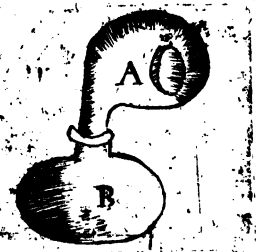
TAke two ounces of *Aqua fortis*, and diſſolve in it halfe an ounce of fine ſilver refined in a Cappell: then take an ounce of *Aqua fortis*, and two drams of Quick-ſilver: which put in it, and mixe theſe two diſſolved things together, then caſt it into a Viall of halfe a pound of water, which may be well ſtopped; for then every day you may ſee it grow both in the Tree and in the branch. This liquid ſerves to black haire which is red, or white, without fading untill they fall; but here is to be noted that great care ought to be had in anointing the haire, for feare of touching the fleſh: for this compoſition is very Corroſive or ſearching, that as ſoone as it toucheth the fleſh it raiſeth bliſters, and bladders very painfull.

PROB.

PROBLEM. CXX.

How to make the representation of the great world?

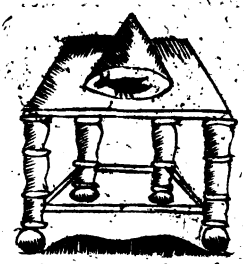
DRaw salt Niter out of salt Earth which is found along the Rivers side, and at the foot of Mountaines, where especially are Minerals of Gold and Silver: mix that Niter well cleansed with ℧, then calcinate it hermetically; then put it in a Limbeck and let the receiver be of Glasse, well luted, and alwayes in which let there be placed leaves of Gold at the bottome; then put fire under the Limbeck, untill vapours arise which will cleave unto the Gold; augment your fire untill there ascend no more, then take away your receiver and close it hermetically, and make a Lampe fire under it untill you may see presented in it that which nature affords us: as *Flowers*, *Trees*, *Fruits*, *Fountaines*, *Sunne*, *Moone*, *Starres*, *&c.* Behold here the forme of the Limbeck, and the receiver: *A* represents the Limbeck, *B* stands for the receiver.



PROBLEM. CXXI.

How to make a Cone, or a Pyramidall body move upon a Table without ſprings or other Artificiall meanes: ſo that it ſhall move by the edge of the Table without falling?

THis propoſition is not ſo thornie and ſubtile as it ſeemes to be, for putting under a Cone of paper a Beetle or ſuch like creature, you ſhall have pleaſure with aſtoniſhment & admiration to thoſe which are ignorant in the cauſe: for this animall will ſtrive alwayes to free herſelf from the captivity in which ſhe is in by the impriſonment of the *Cone*: for comming neere the edge of the Table ſhe will returne to the other ſide for feare of falling.



PROBLEM CXXII.

To cleave an Anvill with the blow of a Piſtoll.

THis is proper to a Warrier, and toperforme it, let the Anvill be heated red hot as one can

can poſſible, in ſuch ſort that all the ſolidity of the body be ſoftned by the fire: then charge the Piſtoll with a bullet of ſilver, and ſo have you infallibly the experiment.

PROBLEM. CXXIII.

How to roſt a Capon carried in a Budget at a Saddle-bowe, in the ſpace of riding 5 or 6 miles?

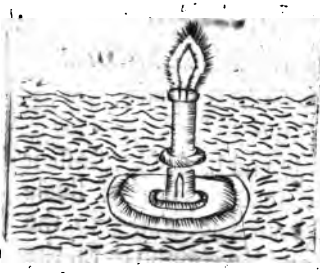
HAving made it ready and larded it, ſtuffe it with Butter; then heat a piece of Iteele which may be formed round according to the length of the Capon, and big enough to fill the Belly of it, and then ſtop it with Butter; then wrap it up well and incloſe it in a Box in the Budget, and you ſhall have your deſire: it is ſaid that *Count Mansfield* ſerved himſelfe with no others, but ſuch as were made ready in this kinde, for that it loſeth none of its ſubſtance, and it is dreſſed very equally.

PROBLEM. CXXIV.

How to make a Candle burne and continue three times as long as otherwiſe it would?

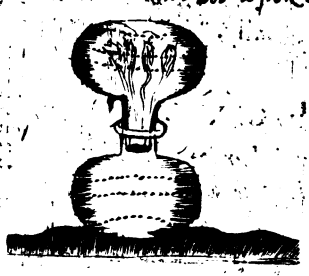
VNto the end of a Candle half burned ſtick a farthing leſſe or more, to make it hang

perpendicular in a veſſel of water, ſo that it ſwimme above the water; then light it, and it will ſuſteine it ſelf & float in this manner; and being placed into a fountaine, pond, or lake that runnes ſlowly, where many people aſſemble, it will cauſe an extreme feare to thoſe which come therein in the night, knowing not what it is.



PROBLEM. CXXV.

How out of a quantitie of wine to extract that which is moſt windy, and evill, that it hurt not a ſick Perſon?



TAke two vials in ſuch ſort that they be of like greatneſſe both in the belly and the neck; fill one of them of wine, and the other of water: let the mouth of that which hath the water be placed into the mouth of that which hath the wine, ſo the water ſhall be

be uppermoſt, now becauſe the water is heavier than the wine, it will deſcend into the other Viall, and the wine which is loweſt, becauſe it is higheſt will aſcend above to ſupply the place of the water, and ſo there will be a mutuall interchange of liquids, and by this penetration the wine wil loſe her vapors in paſſing through the water.

PROBLEME CXXVI.

How to make two Marmouzets, one of which ſhall light a Candle, and the other put it out?

Upon the ſide of a wall make the figure of a Marmouzet or other animall or forme, and right againſt it on the other wall make another; in the mouth of each put a pipe or quill ſo artificially that it be not perceived; in one of which place ſalt peter very fine, and dry and pulveriſed; and at the end ſet a little match of paper, in the other place ſulphur beaten ſmal, then holding a Candle lighted in your hand, ſay to one of theſe Images by way of command, Blow out the Candle; then lighting the paper with the candle, the ſalt-peter wil blow out the Candle immediatly, and going to the other Image (before the match of the Candle be out) touch the ſulphur with it and ſay, Light the Candle, & it will immediatly be lighted, which will cauſe an admiration to thoſe which ſee the action, if it be wel done with a ſecret dexterity.

PROBLEM. XXVII.

How to keepe wine fresh as if it were in a celler though it were in the heat of Summer, and without Ice or snow, yea though it were carried at a saddle bow, and exposed to the Sun all the day?

SEt your wine in a viall of Glasse; and place it in a Box made of wood, Leather, or such like: about which vial place Salt-peeter, and it will preserve it and keep it very fresh: this experiment is not a little commodious for those which are not neare fresh waters, and whose dwellings are much exposed to the Sunne.

PROBLEM. CXXVIII.

To make a Cement which indureth or lasteth as marble, which resisteth aire and water without ever dissolving or uncementing?

TAke a quantity of strong and gluing Morter vvell beaten, mixe vvith this as much nevv slaked Lime, and upon it cast Oile of Olive or Linseed-Oile, and it vvill become hard as Marble being applyed in time.

PROB.

Problem. CXXIX.

How to melt metall very quickly, yea in a ſhell upon a little fire.

MAke a bed upon a bed of metall with pouder of Sulphur, of Salt-peeter, and ſaw-duſt alike; then put fire to the ſaid pouder with a burning Charcole, and you ſhall ſee that the metall will diſſolve incontinent and be in a Maſſe. This ſecret is moſt excellent, and hath been practiſed by the reverend father *Mercenne* of the order of the *Minims*.

Problem. CXXX.

How to make Iron or ſteele exceeding hard?

QVench your Blade or other Inſtrument ſeven times in the blood of a male Hog mixt with Gooſe-greaſe, and at each time dry it at the fire before you wet it: and it will become exceeding hard, and not brittle, which is not ordinary according to other temperings and quenchings of Iron: an experiment of ſmall coſt, often proved, and of great conſequence for *Armorie* in warlike negotiations.

Prob.

Problem CXXXI.

To preſerve fire as long as you will, imitating the inextinguible fire of Veſtales.

After that you have extracted the burning ſpirit of the ſalt of ♄, by the degrees of fire, as is required according to the Art of *Chymiſtrie*, the fire being kindled of it ſelfe, break the Limbeck, and the Irons which are found at the bottome will flame and appeare as burning Coles as ſoone as they feele the aire; which if you promptly incloſe in a viall of Glaſſe, and that you ſtop it exactly with ſome good Lute: or to be more aſſured it may be cloſed up with Hermes wax for feare that the Aire get not in. Then will it keep more than a thouſand yeares (as a man may ſay) yea at the bottome of the Sea; and opening it at the end of the time, as ſoone as it feeles the Aire it takes fire, with which you may light a Match. This ſecret merits to be travelled after and put in practice, for that it is not common, and full of aſtoniſhment, ſeeing that all kinde of fire laſteth but as long as his matter laſteth, and that there is no matter to be found that will ſo long indure.

Artificiall fire-Workes:

Or the manner of making of *Rockets* and *Balls* of fire, as well for the Water, as for the Aire; with the compoſition of Starres, Golden-rain, Serpents, Lances, Wheels of fire and ſuch like, pleaſant and Recreative.

Of the compoſition for Rockets.

IN the making of Rockets, the chiefeſt thing to be regarded is the compoſition that they ought to be filled with; foraſmuch as that which is proper to Rockets which are of aleſſe ſort is very improper to thoſe which are of a more greater forme; for the fire being lighted in a great concave, which is filled with a quick compoſition, burnes with great violence; contrarily, a weak compoſition being in a ſmall concave, makes no effect: therefore we ſhall here deliver in the firſt place rules and directions, which may ſerve for the true compoſition, or matter with which you may charge any Rocket, from Rockets which

are charged but with one ounce of Powder unto great Rockets which requireth for their charge 10 pound of Powder, as followeth.

For Rockets of one ounce.

Vnto each pound of good musket Powder ſmal beaten, put two ounces of ſmal Cole duſt, and with this compoſition charge the Rocket.

For Rockets of 2 or 3 ounces.

Vnto every foure ounces and a halfe of powder duſt, adde an ounce of Salt-peter, or to every 4 ounces of powder duſt, adde an ounce of Cole duſt.

For Rockets of 4 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter. & one ounce of Cole duſt: but to have it more ſlow, unto every 10. ounces of good duſt powder adde 3 ounces of Salt-peter, and 3 ounces of Cole duſt.

For Rockets of 5 or 6 ounces.

Vnto every pound of Powder duſt, adde 3 ounces and a halfe of Salt peter, and 2 ounces and a halfe of Cole duſt, as alſo an ounce of Sulphur, and an ounce of fyle duſt.

For Rockets of 7 or 8 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter, and 3 ounces of Sulphur.

Of Rockets of 10 or 12 ounces.

Vnto the precedent compoſition adde halfe an ounce of Sulphur, and it will be ſufficient.

For Rockets of 14 or 15 ounces.

Vnto every pound of Powder duſt adde 4 ounces of Salt peter, or Cole duſt 2 ½ ounces of Sulphur

Sulphur and file duſt of 1 ¼ ounce.

For Rockets of 1, pound.

Vnto every pound of Powder duſt adde 3 ounces of Cole duſt, and one ounce of Sulphur.

Of Rockets of 2, pound.

Vnto every pound of Powder duſt adde 9 ½ ounces of Salt peter, of Cole duſt 2 ½ ounces, filed duſt 1 ½ ounce, and of Sulphur ¼ of ounce.

For Rockets of 3, pound.

Vnto every pound of Salt peter adde 6 ounces of Cole duſt, and of Sulpher 4, ounces.

For Rockets of 4, 5, 6, or 7, pound.

Vnto every pound of Salt peter adde 5 ounces of Cole duſt, and 2 ½ ounces of Sulphur.

For Rockets of 8, 9, or 10 pound.

Vnto every pound of Salt peter, adde 5 ½ ounces of Cole duſt, and of Sulphur 2 ½ ounces.

Here note that in all great Rockets, there is no Powder put, becauſe of the greatneſſe of the fire which is lighted at once, which cauſeth too great a violence, therefore ought to be filled with a more weaker compoſition.

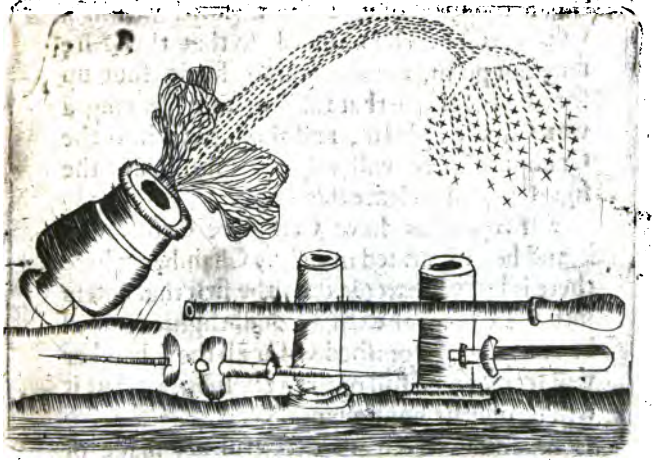
Of the making of Rockets and other Fireworkes.

FOr the making of Rockets of ſundry kindes, divers moulds are to be made, with their Rolling pins, Breaths, Chargers, &c. as may be ſeen here in the figure. And having rolled a Caſe of paper upon the Rolling pin for your mould, fill it with the compoſition belonging to that mould as before is delivered:

now may you load it on the top, with Serpents, Reports, Stars, or Golden Raine: the Serpents are made about the bigneſſe of ones little finger, by rolling a little paper upon a ſmall ſtick, and then tying one end of it, and filling it with the mixt compoſition ſomewhat cloſe, and then tying the other end. The reports are made in their paper-Caſes as the Serpents, but the Paper ſomewhat thicker to give the greater report. Theſe are filled with

graine-Powder or halfe Powder and halfe compoſition, and tying both ends cloſe, they are finiſhed. The beſt kinde of ſtarres are made with this mixture following; unto every 4 ounces of Salt-peter, adde 2 ounces of Sulphur

phur, and to it put 1. ounce of Powder-dust, and of this compoſition make your ſtarres, by putting a little of it within a ſmall quantity of



towe; and then tying it up in the form of a ball as great as an Haſel-Nut or a little Wal-nut, through which there muſt be drawne a little Primer to make it take fire. Touching the making of the Golden Raine, that is nothing but filling of Quilles with the compoſition of your Rockets ſomewhat hard. Now if the head of a Rocket be loaded with a thouſand of thoſe Quilles, its a goodly ſight to ſee how pleaſantly they ſpread themſelves in the Aire, and come downe like ſtreames of Gold much like the falling downe of Snow being agitated by ſome turbulent winde.

Of recreative fires.

1 *Philostrates* saith, that if wine in a platter be placed upon a receiver of burning Coles, to exhale the spirit of it, and be inclosed within a Cupboard or such like place, so that the Aire may not go in, nor out, and so being shut up for 30 yeares, he that shall open it, having a wax Candle lighted, and shall put it into the Cnbboard there will appeare unto him the figure of many cleare starres.

2 If *Aquavita* have Camphire dissolved in it; and be evaporated in a close Chamber, where there is but a Charcole fire, the first that enters into the Chamber with a Candle lighted, will be extremely astonished, for all the Chamber will seeme to be full of fire very subtile, but it will be of little continuance.

3 Candles which are deceitful are made of halfe powder, covered over with Tallow, and the other halfe is made of cleane Tallow, or Waxe, with an ordinary week; this Candle being lighted, and the upper halfe consumed, the powder will take fire, not without great noise and astonishment to those which are ignorant of the cause.

4 A dozen or twenty smal Serpents p'aced secretly under a Candlestick that is indifferent big, which may have a hole passe through the socket of it to the Cardle, through which a piece of primer may be placed, and setting a smal *Candle* in the socket to burne according

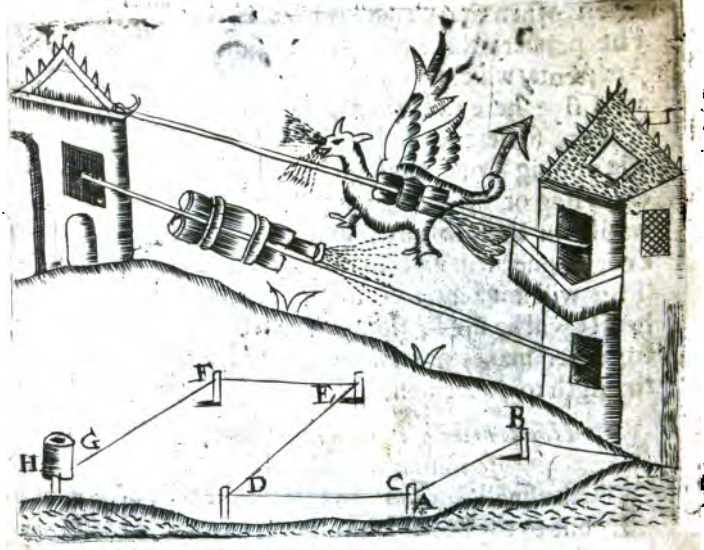
to

to a time limited: which Candleſtick may be ſet on a ſide Table without ſuſpition to any; then when the Candle is burned, that it fires the primer, that immediately will fire all the Serpents, which overthrowing the Candleſtick will flye here and there, intermixing themſelves, ſometimes in the Aire, ſometimes in the Planching, one amongſt another, like the crawling of Serpents, continuing for a pretty while in this poſture, and in extinguiſhing every one will give his report like a Piſtoll; This will not a little aſtoniſh ſome, thinking the houſe will be fired, though the whole powder together makes not an ounce, and hath no ſtrength to do ſuch an effect.

How to make fire run up and downe, forward and backward.

TAke ſmall Rockets, and place the taile of one to the head of the other, upon a Cord according to your fancie, as admit the Cord to be *A B C D E F G*. give fire to the Rocket at *A*, which will flye to *B*, which will come back againe to *A*, and fire another at *C*, that will flie at *D*, which will fire another there, and flie to *E*, and that to *F*, and ſo from *F*, to *G*, and at *G*, may be placed a pot of fire, *viz. G. H.* which fired will make good ſport, becauſe the Serpents which are in it will variouſly intermix themſelves in the Aire, and upon the ground, and every one will extinguiſh with a report: and here may you note that upon the

Rockets may be placed fierie Dragons, Combatants, or ſuch like to meet one another, having

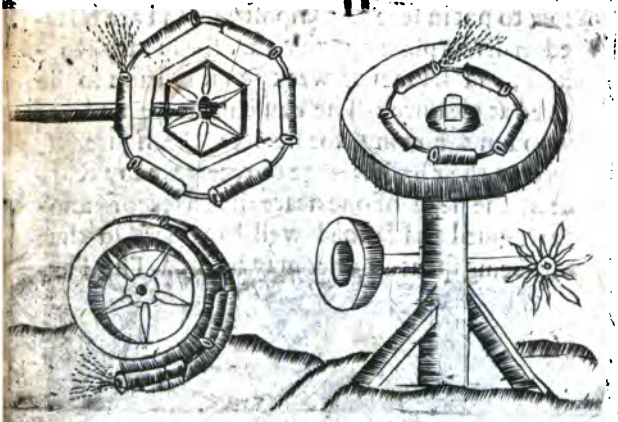


lights placed in the Concavity of their bodies which will give great grace to the action.

How to make Wheels of fire.

TAke a Hoop, and place two Laths acroſſe one the other; upon the croſſing of which make a hole, ſo that it may be placed upon a pin to turne eaſily, as the figure Q. ſheweth upon the ſides of which hoope or round Circle place your Rockets, to which you may place Lances of fire between each Rocket:

Rocket: let this wheele be placed upon a ſtandard as here is repreſented, and place a piece of Primer from one Lance to another, then give fire at *G*, which will fire *F*, that *E*, that will fire



D, that *C*, and that will fire the Rocket at *A*: then immediatly the wheel will begin to move, and repreſent unto the ſpectators a Circle of changeable fire, and if pots of fire be tied to it, you will have fine ſport in the turning of the wheele and caſting out of the Serpents.

Of night-Combatants.

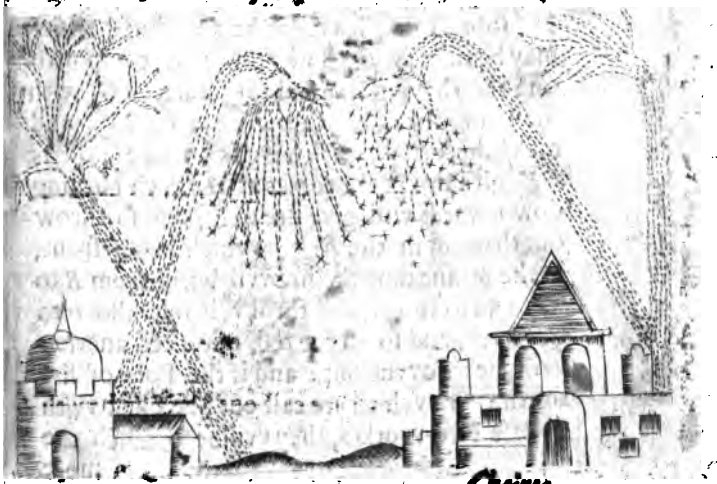
CLubbes, Targets, Faulchons, and Maces charged with ſeverall fires, do make your night-Combatants, or are uſed to make place amongſt a throng of people. The Clubbes at the ends are made like a round Panier with ſmall

ſmall ſticks, filled with little Rockets in a ſpirall forme, glued and ſo placed that they fire but one after another; the Maces are of divers faſhions, ſome made oblong at the end, ſome made of a ſpirall forme, but all made hollow to put in ſeveral compoſition, and are boared in divers places, which are for ſundry Rockets, and Lances of weak compoſition to be fired at pleaſure: The Faulchons are made of wood in a bowing forme like the figure *A*, having their backes large to receive many Rockets, the head of one neare the neck of another, glued and faſtned well together, ſo that one being ſpent another may be fired. The Targets are made of woodenthinne boards, which are channeled in ſpiral lines to containe primer

to fire the Rockets one after another, which is all covered with thinne covering of wood, or Paſtboard, boared with holes ſpirally alſo; which *Rockets* muſt be glued and made faſt to the place of the Channels: Now if two men, the one having a Target in his hand, and the other a Falchon, or Mace of fire, ſhall begin to fight, it will appeare very pleaſant to the Spectators: for by the motion of fighting, the place will ſeem to be ful of ſtreames of fire; and there may be adjoyned to each Target a Sunne or a burning Comet with Lances of fire, which will make them more beautifull and reſplendent in that action.

Of ſtanding Fires.

SVch as are uſed for recreation, are *Colloſſus*, *Statues*, *Arches*, *Pyramides*, *Chariots*,



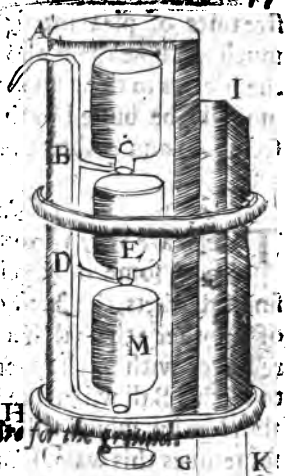
Chaires

Chaires of triumph and ſuch like, which may be accommodated with Rockets of fire, and beautified with ſundry other artificiall fires; as pots of fire for the Aire which may caſt forth ſeverall figures, Scutchions, Rockets of divers ſorts, Starres, Crownes, Leaters, and ſuch like, the borders of which may be armed with ſundry Lances of fire, of ſmall flying Rockets with reports, flames, of ſmall birds of Cypres, Lanthornes of fire, Candles of divers uſes, and colours in burning, and whatſoever the fancie of an ingenious head may alude unto.

Of Pots of fire for the Aire, which are throwne out of one Caſe one after another of a long continuance.

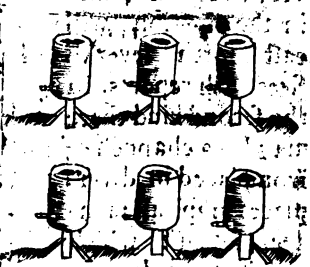
MAke a long Trunk as *A G*, and by the ſide *A H*, let there be a Channel which may be fiered with ſlow primer or compoſition; then having charged the Trunk *A G*, with the Pots of fire for the Aire at *I G E C*, and make the Trunk *A G*, very faſt unto a Poſt as *I K*, give fire at the top as at *A*, which burning downewards will give fire to *C*, and ſo throw out that Pot in the Aire, vvhich being ſpent, in the meane time the fire vvill burne from *B* to *D*, and ſo fire *E*, and throvv it out alſo into the Ayre, and ſo all the reſt one after another vvill be throvvne out: and if the Pots of fire for the Aire vvhich are caſt out, be filled vvith diverſe Fire-vvorkes, they vvillbe ſo much the more

more pleasant to the beholders. These Trunks of fire doe greatly adorne a Firevvorke, and may conveniently be placed at each angle of the vvhole vvorke.



Of Pots of fire for the ground.

MAny Pots of fire being fired together do give a fine representation, and recreation to the spectators, and cause a vvonderfull shout amongst the common people vvch are standers by; for those Pots being filled vvith Balles of fire and flying Serpents for the Aire, they vvill so intermix one vvithin another, in flying here and there a little above the ground, and giving such a volley of reports that the Aire vvill rebound vvith their noise, and the vvhole place be filled vvith sundry



streames

ſtreames of pleaſant fire; which ſerpents will much occupie theſe about the place to defend themſelves in their upper parts, when they will no leſſe be buſied by the balls of fire, which ſeeme to annoy their feet.

Of Balles of fire.

THeſe are very various according to a mans fancy; ſome of which are made with very ſmall Rockets, the head of one tyed to the neck of another: the ball being made may be covered over with pitch except the hole to give fire to it; this Ball will make fine ſport amongſt the ſtanders by, which will take all a fire, and rolle ſometimes this way, ſometimes that way, between the legs of thoſe that are ſtanders by, if they take not heed, for the motion will be very irregular, and in the motion will caſt forth ſeverall fires with reports. In the ſecond kind there may be a channell of Iron placed in divers places in ſpirall manner, againſt which

may be placed as many ſmall petards of paper as poſſible may be, the Channell muſt be full of ſlow compoſition, and may be covered as the former, and made fit with his Rockets in the middle: this Ball may be ſhot out of a

morter-

morter Peece, or charged on the top of a Rocket; for in its motion it will flye here and there, and give many reports in the Aire: because of the discharge of the petards.

Of fire upon the Water.

PLaces which are situated upon Rivers or great Ponds, are proper to make Recreative fires on: and if it be required to make some of consequence, such may conveniently be made upon two Boats, upon which may be built two *Beasts*, *Turrets*, *Pagins*, *Castles*, or such like,

to receive or hold the diversity of Fire workes that may be made within it, in which may play divers fires, Petards, &c. and cast out many simple Granadoes, Balls of fire to burne in the

water,

water Serpents and other things, and often times these bodies in their incounters may hang one in another, that so the Combatants with the Targets, and Maces may fight; which will give great content to the eyes of those which are lookers on, and in the conclusion fire one another, (for which end they were made:) by which the dexterity of the one may be knowne in respect of the other, and the triumph and victory of the fight gotten.

Of Balls of fire which move upon the water.

THese may be made in forme of a Ball stuffed with other little Balls, glued round about and filled with composition for the water, which fiered, will produce marvellous and admirable effects, for which there must be had little Cannons of white Iron, as the ends of small funnels: these Iron Cannons may be pierced in sundry places, to which holes, may be set small Balles ful of composition for the water which small Balls must be peirced deep and large, and covered with Pitch, except the hole: in which hole must be first placed a little quantitie of grain-Powder; and the rest of the hole filled up with composition: and note further that these Iron Cannons, must

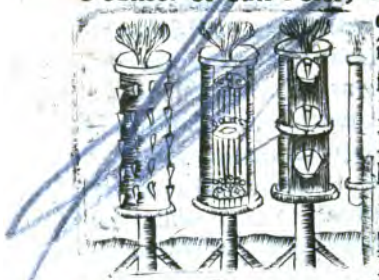
be

be filled with a slow composition; but such which is proper to burne in the water: then must these Cannons with their small Balls be put so together that it may make a Globe, and the holes in the Cannons be answerable to the hollow Balls; and all covered over with Pitch and Tallow; afterwards pierce this Ball against the greatest Cannon (to which all the lesser should answer) unto the composition, then fire it; and when it begins to blow, throw it into the water, so the fire comming to the holes will fire the graine Powder, the which will cause the Balls to separate and fly here and there, sometimes two at a time, sometimes three, sometimes more; which will burne within the water with great astonishment and content to those which see it.

Of Lances of fire.

STanding Lances of fire, are made commonly with hollow wood, to containe sundry Petards, or Rockets, as the figure here sheweth, by which is easie to invent others according to ones fancy. These Lances have wooden handles, that so they may be fastned at some Post, so that they be not overthrowne in the flying out of the Rockets or Petards: there are lesser sorts of Lances whose cases are of three or foure foulding of Paper of a foote long, and about the bigheſſe of ones finger, which are filled with a composition for Lances. But if these Lances be filled with a composition,

on, then (unto every 4 ounces of powder adde 2 ounces of Salt-Peter, and unto that adde 1 ounce of Sulphur) it will make a brick fire red before it be halfe ſpent, if the Lance be fiered and held to it: and if 20 ſuch Lances were placed about a great Rocket and ſhot to a houſe or ſhip, it would produce a miſchievous effect.



How to ſhoot a Rocket Horizontall, or otherwiſe.

VNto the end of the Rocket place an Arrow which may not be too heavy, but in ſtead of the feathers let that be of thinne white tinne plate, and place it upon a reſt, as here you may ſee by the Figure, then give fire unto it, and you may ſee how ſerviceable it may be. To the head of ſuch Rockets, may be placed Retards, Balls of fire, Granadoes, &c. and ſo may be applyed to warlike affaires.

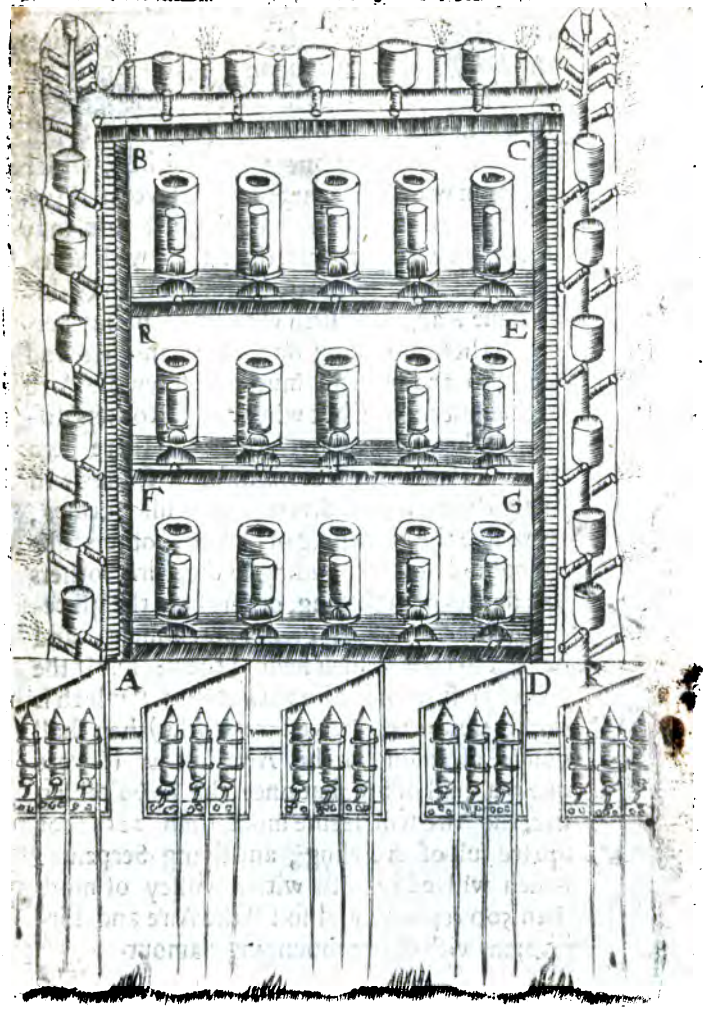
How

How a Rocket burning in the water for a certaine time, at laſt ſhall fly up in the Aire with an exceeding quickneſs.

TO do this, take two Rockets, the one equall to the other, and joyne them one unto another in the middle at *C.* in ſuch ſort that the fire may eaſily paſſe from one to another: it being thus done, tye the two Rockets at a ſtick in *D*, and let it be ſo long and great that it may make the Rockets in the water hang, or lye upright: then take a pack-thread and tye it at *G.* and let it come double about the ſtick *D M.* at *H.* and at that point hang a Bullet of ſome weight as *K.* for then giving fire at *A.* it will burne to *B.* by a ſmall ſerpent filled there and tyed at the end, and covered ſo that the water injure it not, which will fire the Rocket *B D*, and ſo mounting quick out of the water by the looſe tying at *C.* and the Bullet at the pack-thread, will leave the other Rocket in the vvater: and ſo aſcend like a Rocket in the Aire, to the admiration of ſuch as knovv not the ſecrecie.

Of the framing of the parts of a Fire-Worke, together, that the severall workes may fire one after another.

CAuse a frame to be made as *A B C D.* of two foot square every way, or thereabouts (according to the quantity of your severall workes) then may you at each angle have a great Lance of fire to stand, which may cast out Pots of fire as they consume: upon the ledges *A B. B C.* and *C D.* may be placed small Lances of fire about the number of 30 or 60, some sidewise, and others upright, betweene these Lances may be placed Pots of fire sloping outwards, but made very fast, and covered very close, that they chance not to fire before they should; then upon the ledges *R E. F G. H I.* and *A D* may be placed your foucisons, and behinde all the work may be set your Boxes of Rockets, in each of which you may place 6, 9, 12. or 20 small Rockets: Now give fire at *A.* (by help of a piece of primer going from one Lance to another) all the Lances will instantly at once be lighted, and as soone as the Lance at *A* is consumed, it will fire the Channell which is made in the ledge of the frame which runnes under the Pots of fire, and as the fire goes along burning, the Pots will be cast forth, and so the rank of Pots upon the sides of the frame *A B. B C.* and *C D.* being spent, the foucisons will begin to play being fiered also by a Channel which runnes under them, upon the


B
C
E
F
G
A
D

the ledges *A D*, *H I*, *F G*, and *R E*. then when the *Souciſons* are ſpent upon the laſt ledge *R E*. there may be a ſecret Channel in the ledge *C D* which may fire the Box of Rockets at *K*. and may fire all the reſt one after another, which Boxes may be all charged with ſeverall Fire-Workes: for the Rockets of the firſt Box may be loaden with Serpents, the ſecond with Stars, the third with Reports, the fourth with Golden raine, and the fifth with ſmall flying Serpents; theſe mounting one after another and flying to and fro will much inlighten the Aire in their aſcending, but when theſe Rockets diſcharge themſelves above, then will there be a moſt pleaſant repreſentation, for theſe fires will dilate themſelves in divers beautifull formes, ſome like the branching of Trees, others like fountaines of water gliding in the Aire, others like flaſhes of lightning, others like the glittering of ſtarres, giving great contentment, and delight to thoſe which behold them; But if the worke be furniſhed alſo with *Balons* (which is the chiefeſt in recreative Fire-works) then ſhall you ſee aſcending in the Aire but as it were onely a quill of fire, but once the *Balon* taking fire, the Aire will ſeeme more than 100. foot ſquare full of crawling, and flying Serpents, which will extinguiſh with a volley of more than 500 reports: and ſo fill the Aire and Firmament with their rebounding clamour.

The

The making of which with many other rare and excellent Fire-workes, and other practiſes, not onely for recreation, but alſo for ſervice: you may finde in a book intituled *Artificiall Fire-workes*, made by Mr. *Malthus* (a maſter of his knowledge) and are to be ſold by *William Leake*, at the Crowne in Fleet-ſtreet, between the two Temple-Gates.

Concluſion.

In this Booke we have nothing omitted what was materiall in the originall, but have abundantly augmented it in ſundry experiments: And though the examinations are not ſo full, and manifold; yet (by way of brevitie) we have expreſſed fully their ſubſtance, to avoid prolixitie, and ſo paſt by things reiterated.

FINIS.

Printed or sold by *William Lee*, at the Crowne in Fleetstreet neere the Temple, *these Books following.*

York's Heraldry, Folio
A Bible of a very fair large Roman letter, 4o
Orlando Furioso Folio.
Callis learned Readings on the Stat. 23. *Hen.* 8o. Cap. 5 of Sewers
Perkins on the Laws of *England.*
Wilkinsons Office of Sheriffs.
Vade Mecum, of a Justice of Peace.
The book of Fees.
Peasons Law.
Mirrour of Justice.
Topicks in the Laws of *England.*
Skeu de significatione Verborum.
Delaman's use of the Horizontal Quadrant.
wilby's 2d set of Musique, 3 4 5 and 6 Parts.
Corderius in English.
Doctor *Fulk's* Meteors.
Malthus Fire-works.
Nye's Gunnery & Fire-workes Care Major with Annotations, by *Wil. Austin* Esquire.
Mel Helliconium, by *Alex. Roffe.*
Nosce teipsum, by Sr *John Davis*
Animadversions on *Lillies* Grammer.
The History of *Vienna*, & Paris
Lazarillo de Tormes.
Hero and *Leander*, by *G. Chapman* and *Christoph. Marlow.*
Alcilia or *Philotas* loving folly.
Bishop *Andrews* Sermons.
Adams on *Peter.*
Posing of the Accidence.
Amadis de Gaule.
Guillielm's Heraldry.
Herberts Travels.
Bacons Tales.
Man become guilty, by *John Francis Senalt*, and Englished by *Henry* Earl of Monmouth.
The Ideot in 4 books; the first and second of Wisdom; the third of the Mind; the fourth of Statick Experiments of the Ballance.
The life and Reign of *Hen.* the Eighth, written by the L. *Herbert*
Cornwallis Essays, & Paradoxes.
Clenards greek Grammar 8o
Aula lucis, or the house of light: A discourse written in the year 1651, by *S N.* a modern Speculator.
A Tragedy written by the most learned *Hugo Grotius* called *Christus Patience*, and translated into Engl. by *George Sandys*
The Mount of Olives: or Solitary Devotions, by *Henry Vaughan Silurist* With an excellent discourse of Man in glory, written by the Reverend *Anselm* Arch Bishop of Canterbury.
The Fort Royall of Holy Scripture by *I. H.*

PLAYES.

Hen. the Fourth. *Philaster.*
The wedding. The Hollander.
Maids Tragedie. King & no King.
The gratefull Servant.
The strange Discovery.
Othello, the Moor of *Venice.*
The Merchant of *Venice.*

THE DESCRIPTION AND USE OF THE DOVBLE Horizontall Dyall.

WHEREBY NOT ONELY THE Houre of the Day is ſhewn; but alſo the *Meridian Line* is found:

And moſt ASTRONOMICALL Queſtions, which may be done by the GLOBE: are reſolved.

INVENTED AND WRITTEN BY W. O.

Whereunto is added, The Deſcription of the generall HOROLOGICALL RING.

LONDON,
Printed for WILLIAM LEAKE, and are to be ſold at his Shop at the ſigne of the *Crown* in *Fleetſtreet*, between the two *Temple* Gates. 1652.

The deſcription, and uſe of the double *Horizontall Diall.*

THere are upon the Plate two ſeverall Dyals. That which is outermoſt, is an ordinary diall, divided into houres and quarters, and every quarter into three parts which are five minutes a piece: ſo that the whole houre is underſtood to contein 60 minutes. And for this dyall the ſhadow of the upper oblique, or ſlanting edge of the ſtyle, or cocke, doth ſerve.

The other diall, which is within, is the *projection of the upper Hemiſphere, upon the plain of the Horizon: the Horizon* it ſelf is underſtood to be the innermoſt circle of the limbe: and is divided on both ſides from the points of *Eaſt* and *Weſt* into degrees, noted with 10. 20. 30, &c. As far as need requireth: And the center of the Inſtrument is the *Zenith*, or *Verticall point*.

Within the *Horizon* the middle ſtraight line pointing *North* and *South* upon which the ſtyle ſtandeth, is the *Meridian* or twelve a clock line: and the other ſhort arching lines on both ſides of it, are the *houre lines*, diſtinguiſhed accordingly by their figures: and are divided into quarters by the ſmaller lines drawn between them: every quarter conteining 15 minutes.

The two arches which croſſe the houre lines, meeting on both ſides in the points of interſection of the five a clocke lines with the Horizon, are the two ſemicircles of the *Ecliptick* or annuall circle of the ſun: the upper of which arches ſerveth for the *Summer* halfe yeere; and the lower for the *Winter* halfe yeer: and therefore divided into 365 dayes: which are alſo diſtinguiſhed into twelve moneths with longer lines, having their names ſet down: and into tenths and fifts with ſhorter lines:

and

and the rest of the dayes with pricks as may plainly be seene in the diall.

And this is for the ready finding out of the *place of the Sun every day*: and also for the shewing of the *Suns yeerely motion*, because by this motion the Sun goeth round about the heavens in the compasse of a yeer, making the four parts, or seasons thereof, namely, the *Spring* in that quarter of the *Ecliptick* which begins at the *intersection on the East* side of the diall, and is therefore called the *Vernall intersection*. Then the *Summer* in that quarter of the *Ecliptick* which begin at the *intersection with the Meridian* in the highest point next the *Zenyth*. After that, *Autumne* in that quarter of the *Ecliptick*, which beginneth at the *intersection* on the *West* side of the diall, and is therefore called the *Autumnall intersection* and lastly, the *Winter* in that quarter of the *Ecliptick*, which beginneth at the *intersection, with the Meridian* in the lowest point next the *Horizon*.

But besides this *yeerely motion, the Sun* hath a *diurnall*, or *daily motion*, whereby it maketh day and night, with all the diversities and inæqualities thereof: which is expressed by those other *circles drawn crosse the houre lines*; the middlemost whereof, being grosser then the rest, meeting with the *Ecliptick* in the points of the *Vernall* and *Autumnall intersections*, is the *Equinoctiall*: and the rest on both sides of it are called the parallels, *or diurnall arch of the Sun*, the two outermost whereof are the *Tropicks*, because in them the sun hath his furthest *digression* or *Declination* from the *Æquinoctiall*, which is degrees $23\frac{1}{2}$: and thence beginneth againe to return towardst he *Equinoctiall*. The upper of the two *Tropicks* in this our Northerne *Hemisphere* is the *Tropick* of *Cancer*, and the sun being in it, is highest into the North, ma-

king the longeſt day of Summer : And the lower next the *Horizon* is the *Tropick* of *Capricorne* ; and the ſun being in it, is loweſt into the *South*, making the ſhorteſt day of winter.

Between the two *Tropicks* and the *Æquinoctiall*, infinite ſuch *parallel circles* are underſtood to be conteined : for the ſun, in what point ſoever of the *Ecliptick* it is carried, deſcribeth by his *Lation* a circle parallel to the *Æquinoctiall* : yet thoſe parallels which are in the inſtrument, though drawn but to every ſecond degree of *Declination*, may be ſufficient to direct the eye in imagining and tracing out through every day of the whole yeere in the *Ecliptick*, a proper circle which may be the diurnall *arch of the ſun* for that day. For upon the right eſtimation of that imaginary parallel doth the manifold uſe of this inſtument eſpecially rely : becauſe the true place of the ſun all that day is in ſome part or point of that circle. Wherefore for the better conceiving and bearing in minde thereof, every fift *parallel* is herein made a little groſſer then the reſt.

For this inner diall ſerveth the ſhadow of the upright edge of the ſtyle ; which I therefore call the *uprights ſhadow*.

And thus by *the eye and view onely to behold and comprehend the courſe of the ſun, throughout the whole yeere both for his annuall and diurnall motion*, may be the firſt uſe of this inſtrument.

II Uſe. To finde the *declination of the ſun* every day.

Looke the day of the moneth propoſed in the *Ecliptick*, and mark how many degrees the prick ſhewing that day, is diſtant from the *Equinoctiall*, either on the Summer or Winter ſide, *viz.* North or South.

Example

Example 1. What will the *Declination* of the ſun be upon the eleventh day of *Auguſt*? look the eleventh day of *Auguſt*, and you ſhall finde it in the ſixth circle above the *Equinoctiall*: Now becauſe each parallel ſtandeth (as hath been ſaid before) for two degrees, the ſun ſhall that day decline Northwards 12. degrees.

Example 2. What declination hath the ſun upon the 24 day of *March*? look the 24 day of *March*, and you ſhall finde it betweene the ſecond and third northern parallels, as it were an half and one fift part of that diſtance from the ſecond: Reckon therefore four degrees for the two circles, and one degree for the halfe ſpace: So ſhall the Suns declination be five degrees, and about one fift part of a degree Northward that ſame day.

Example 3. What declination hath the ſun upon the 13 day of *November*? look the 13 day of *November*, and you ſhall finde it below the *Equinoctiall* ten parallels, and about one quarter which is 20 degrees and an halfe ſouthward. So much is the declination. And according to theſe examples judge of all the reſt.

III. Uſe. *To finde the diurnall arch, or circle of the ſuns courſe every day.*

The ſun every day by his motion (as hath been ſaid) deſcribeth a circle parallel to the *Equinoctiall*, which is either one of the circles in the diall, or ſome-where betweene two of them. Firſt, therefore ſeek the day of the moneth; and if it fall upon one of thoſe parallels; that is the circle of the ſuns courſe that ſame day: But if it fall betweene any two of the parallels, imagine in your minde, and eſtimate with your eye, another parallel through that point betweene thoſe two parallels keeping ſtill the ſame diſtance from each of them.

As in the firſt of the three former examples, The circle of the Suns courſe upon 11 of Auguſt, ſhal be the very ſixt circle above the *Equinoctiall* toward the center.

In example 2. The circle of the *ſuns courſe* upon the 24 of March ſhall be an imaginary circle between the ſecond and third parallels ſtill keeping an half of that ſpace and one fifth part more of the reſt, from the ſecond.

In example 3. The *circle of the ſuns courſe* upon the 13 of November ſhall be an imaginary circle between the tenth and eleventh parallels below the *Equinoctiall*, ſtill keeping one quarter of that ſpace from the tenth.

IIII Uſe. *To finde the riſing and ſetting of the ſun every day.*

Seek out (as was laſt ſhewed) the imaginary circle or parallel of the ſuns courſe for that day, and marke the point where it meeteth with the horizon, both on the *Eaſt* and *Weſt* ſides, for that is the very point of the ſuns riſing, and ſetting that ſame day, and the houre lines which are on both ſides of it, by proportioning the diſtance reaſonably, according to 15 minutes for the quarter of the houre, will ſhew the houre of the ſuns riſing on the *Eaſt* ſide, and the ſuns ſetting on the *Weſt* ſide.

V Uſe. To know the reaſon and manner of the *Increaſing* and *decreaſing* of the *dayes and nights* throughout the whole yeere.

When the Sun is in the *Equinoctiall*, it riſeth and ſetteth at 6 a clock, for in the inſtrument the interſection of the *Equinoctiall* and the *Ecliptick* with the *Horizon* is in the ſix a clocke circle on both ſides. But if the ſun be out of the *Equinoctial*, declining toward the *North*, the interſections of the parallel of the ſun with the *Horizon* is

before 6 in the morning, and after 6 in the evening: and the *Diurnall arch* greater then 12 houres; and so much more great, the greater the Northerne Declination is. Againe, if the sun be declining toward the South, the intersections of the parallel of the sun, with the *Horizon* is after 6 in the morning, and before 6 in the evening: and the *Diurnall arch* lesser then 12 houres; and by so much lesser, the greater the Southerne Declination is.

And in those places of the *Ecliptick* in which the sun most speedily changeth his declination, the length also of the day is most altered: and where the *Ecliptick* goeth most parallel to the *Equinoctiall* changing the declination, but little altered. As for example, when the sun is neer unto the *Equinoctiall* on both sides, the dayes increase and also decrease suddenly and apace; because in those places the *Ecliptick* inclineth to the *Equinoctiall* in a manner like a streight line, making sensible declination. Again, when the sun is neere his greatest declination, as in the height of Summer, and the depth of Winter, the dayes keep for a good time, as it were, at one stay, because in these places the *Ecliptick* is in a manner parallel to the *Equinoctiall*, the length of the day also is but little, scarce altering the declination: And because in those two times of the yeer, the sun standeth as it were still at one declination, they are called the *summer solstice*, and *winter solstice*. And in the mean space the neerer every place is to the *Equinoctiall*, the greater is the diversity of dayes.

Wherefore, we may hereby plainly see that the common received opinion, that in every moneth the dayes dos equally increase, is erroneous.

Also we may see that in parallels equally distant from the *Equinoctiall*, the day on the one side is equall to the night on the other side.

VI. Vſe. *To finde how far the ſun riſeth, and ſetteth from the true eaſt and weſt points, which is called the ſun Amplitude ortive, and occaſive.*

Seek out (as was ſhewed in III *Vſe*) the imaginary circle, or parallel of the ſuns courſe, and the point of that circle in the *horizon*, on the Eaſt and Weſt ſides cutteth the degree of the *Amplitude ortive*, and *occaſive.*

VII Vſe. *To finde the length of every day and night.*

Double the houre of the ſunnes ſetting, and you ſhal have the length of the day; & double the houre of the ſunnes riſing, and you ſhal have the length of the night.

VIII Vſe. *To finde the true place of the ſun upon the dyall, that is, the point of the inſtrument which anſwereth to the place of the ſun in the heavens at any time, which is the very ground of all the queſtions following.*

If the dyall be fixed upon a poſt: Look what a clock it is by the outward dyall, that is, look what houre and part of houre the ſhadow of the flanking edge of the ſtyle ſheweth in the outward limbe. Then behold the ſhadow of the upright edge, and marke what point thereof is upon that very houre and part in the inner dyall among the parallels, that point is the true place of the Sunne at the ſame inſtant.

If the dyal be not fixed, and you have a *Meridian line* noted in any window where the Sunne ſhineth: place the *Meridian* of your dyal upon the *Meridian* line given, ſo that the top of the ſtile may point into the north: and ſo the dyal is as it were fixed, wherefore by the former rule you may finde the place of the Sunne upon it.

If the dyal be not fixed, neither you have a Meridian line, but you know the true houre of the day exactly: hold the dyal even and parallel to the Horizon, moving

it

it till the ſlanting edge of the ſtile caſt his ſhadow juſtly upon the time or houre given; for then the dyal is truly placed, as upon a poſt. Seek therefore what point of the upright ſhadow falleth upon that very houre, and there is the place of the Sun.

But if your dyal be looſe, and you know neither the Meridian nor the time of the day. Firſt, by the day of the moneth in the Ecliptique, finde the ſuns parallel, or diurnall arch for that day, then holding the dyal level to the horizon, move it every way untill the ſlanting ſhadow of the ſtyle in the outward limbe, and the upright ſhadow in the Sunnes diurnal arch, both ſhew the very ſame houre and minute, for that very point of the Sunnes parallel, which the upright ſhadow cutteth, is the true place of the Sun on the dyal at that preſent.

But note that by reaſon of the thicknes of the ſtyle, and the bluntneſſe of the angle of the upright edge, the Sun cannot come unto that edge for ſome ſpace before and after noone. And ſo during the time that the Sunne ſhineth not on that upright edge, the place of the Sunne in the dyal cannot be found. Wherefore they that make this kinde of double dyal, are to be careful to file the upright edge of the ſtyle as thinne and ſharpe as poſſible may be.

That which hath here bin taught concerning the finding out the Suns true place in the dyal, ought perfectly to be underſtood, that it may be readily, and dexteriouſly practiſed, for upon the true performance thereof dependeth all that followeth.

IX Vſe. *To finde the houre of the day.*

If the dyal be faſtned upon a poſt, the houre by the outward dyal, or limbe, is known of every one, and the upright

upright ſhadow in the Suns parallel, or diurnal arch will alſo ſhew the very ſame houre.

But if the dyall be looſe, either hold it or ſet it parallel to the Horizon, with the ſtyle pointing into the north and move it gently every way untill the houre ſhewn in both dialls exactly agreeth, or which is all one, find out the true place of the Sun upon the dyall, as was taught in the former queſtion, for that point among the houre lines ſheweth the houre of the day.

X Vſe. *To finde out the Meridian, and other points of the Compaſſe.*

Firſt, you muſt ſeek the true houre of the day (by the laſt queſtion) for in that ſituation the Meridian of the dyall ſtandeth directly north and ſouth: and the eaſt pointeth into the eaſt, and the weſt into the weſt, and the reſt of the points may be given by allowing degrees 11. $\frac{1}{4}$ unto every point of the compaſſe.

XI Vſe. *To finde out the Azumith of the ſun, that is, the diſtance of the Verticall circle, in which the ſun is at that preſent, from the Meridian.*

Set your diall upon any plain or flat, which is parallel to the horizon, with the Meridian pointing directly north or ſouth, as was laſt ſhewed: then follow with your eye the upright ſhadow in a ſtreight line, till it cutteth the *horizon*: for the degree in which the point of interſection is, ſhal ſhew how far the ſuns *Azumith* is diſtant from the eaſt and weſt points, and the complement thereof unto 90; ſhal give the diſtance thereof from the meridian.

XII Vſe. *To finde out the Declination of any Wall upon which the ſun ſhineth, that is, how far that wall ſwerveth from the north or ſouth, either eaſtward or weſtward.*

Take

Take a board having one ſtreight edg, & a line ſtrickn perpendicular upon it; apply the ſtreight edg unto the wall at what time the ſun ſhineth upon it, holding the board parallel to the horizon: Set the dyal thereon, and moye it gently every way, until the ſame hour and minute be ſhewed in both dyals: and ſo let it ſtand: then if the dyal have one of the ſides parallel to the Meridian ſtrike a line along that ſide upon the board, croſſing the perpendicular, or elſe with a bodkin make a point upon the board, at each end of the meridian, and taking away the inſtrument from the board, and the board from the wall, lay a ruler to thoſe two points, and draw a line croſſing the perpendicular: for the angle which that line maketh with the perpendicular, is the angle of the declination of the wall. And if it be a right angle, the wall is exactly eaſt or weſt: but if that line be parallel to the perpendicular, the wall is direct north or ſouth without any declination at all.

You may alſo finde out the declination of a wall, if the dial be fixed on a poſt not very far from that wall; in this manner. Your board being applyed to the wall, as was ſhewed, hang up a thred with a plummet, ſo that the ſhadow of the thred may upon the board croſſe the perpendicular line: make two pricks in the ſhadow and run inſtantly to the dyal and look the horizontal diſtance of the ſuns Azumith, or upright ſhadow from the meridian. Then through the two pricks draw a line croſſing the perpendicular: and upon the point of the interſection, make a circle equal to the horizon of your Inſtrument, in which Circle you ſhal from the line through the two pricks meaſure the Horizontal diſtance of the upright ſhadow, or Azumith from the meridian, that way toward which the Meridian is: draw

a line

a line out of the center, to the end of that arch measured and the angle which this last line maketh with the perpendicular, shall be equall to the declination of the wall.

XIII Vse. *How to place the dyall upon a post without any other direction but it selfe.*

Set the dyall upon the post, with the stile into the North, as neere as you can guesse: then move it this way and that way, till the same houre and minute be shewed both in the outward and inward dials by the severall shadowes, as hath been already taught, for then the dyall standeth in its truest situation; wherefore let it be nailed down in that very place.

XIIII Vse. *To finde the height of the sun at high noon every day.*

Seeke out the diurnall Arch or parallel of the suns course for that day, (by *Vse III.*) and with a paire of Compasses, setting one foot in the center, and the other in the point of intersection of that parallel with the Meridian, apply that same distance unto the Semidiameter divided: for that measure shal therein shew the degree of of the Suns altitude above the the Horizon that day at high noon.

XV *Vse. To finde the height of the sun at any houre or time of the day.*

Seeke out the diurnal Arch, or parallel of the suns course for that day: and marke what point of it is in the very houre and minute proposed. And with a paire of Compasses, setting one foot in the Center, and the other in that point of the parallel, apply the same distance upon the Semidiameter divided: for that measure shall shew the degree of the suns altitude above the Horizon at that time.

And

And by this meanes you may finde the height of the
n above the Horizon at every houre throughout the
ole yeere, for the making of rings and cylinders and
er instruments which are used to shew the houre of the
y.

XVI. Vse. *The height of the sun being given, to finde
the houre, or what it is a clocke.*

This is the converse of the former: Seeke therefore in
Semidiameter divided, the height of the sun given.
d with a paire of Compasses, setting one foot in the
ter, and the other at that height, apply the same di-
nce unto the diurnall arch, or parallel of the Sun for
day: for that point of the diurnall arch, upon which
e same distance lights, is the true place of the sun upon
dial; and sheweth among the houre lines, the true
e of the day.

XVII Use. *Considerations for the use of the instrument
the night.*

In such questions as concerne the night, or the time
fore sun rising, and after sun setting, the instrument re-
senteth the lower Hemisphære, wherein the *Southerne*
e is elevated. And therefore the parallels which are
ve the Æquinoctiall toward the center, shall be for
Southerne, or winter parallels: and those beneath
Æquinoctiall, for the Northerne or Summer pa-
lels; and the East shall be accounted for West, and
West for East; altogether contrary to that which
before, when the Instrument represented the upper
misphære.

XVIII. Use. *To finde how many degrees the sun is un-
the Horizon at any time of the night.*

Seeke the Declination of the sun for the day propo-
sed

ſed (by *Vſe II.*) And and at the ſame declination the contrary ſide imagine a parallel for the ſun that night: and mark what point of it is in the very houre and minute propoſed: And with a pair of compaſſes, ſetting one foot in the center, and the other in that point of the parallel, apply that ſame diſtance unto the ſemidiameter divided: for that meaſure ſhall ſhew the degree of the ſun depreſſion below the Horizon at that time.

XIX Uſe. *To finde out the length of the Crepuſculum or twylight, every day.*

Seek the declination of the ſun for the day propoſed (by *Vſe II.*) And at the ſame declination on the contrary ſide imagine a parallel for the ſun that night. And with a paire of compaſſes ſetting one foot in the center, and the other at 72 degrees upon the ſemidiameter divided, apply that ſame diſtance, unto the ſuns nocturnall parallel for that point of the parallel, upon which that ſame diſtance ſhall light, ſheweth among the houre lines, the beginning of the twilight in the morning, or the end of the twilight in the evening.

XX Uſe. *If the day of the moneth be not known, to find it out by the dyall.*

For the working of this queſtion, either the diall muſt be fixed rightly on a poſt, or elſe you muſt have a true Meridian line drawn in ſome window where the ſun ſhineth, wherefore ſuppoſing the diall to be juſtly ſet either upon the poſt, or upon the Meridian, Look what a clock it is by the outward diall, and obſerve what point of the upright ſhadow falleth upon the very ſame minute in the inner diall, and through that ſame point imagine a parallel circle for the ſuns courſe; that imaginary circle in the *Ecliptick* ſhall cut the day of the moneth.

Of

Of the Generall Horilogicall Ring.

I. *The deſcription of it.*

THis Inſtrument ſerveth as a Diall to finde the houres of the day, not in one place onely (as the moſt part of Dials do) but generally in all Countreys lying North of the *Æquinoctiall*, and therefore I call it the generall Horologicall *Ring*.

It conſiſteth of two brazen circles: a Diameter, and a little Ring to hang it by.

The two circles are ſo made, that though they are to be ſet at right angles, when you uſe the Inſtrument: yet for more convenient carrying, they may be one folded into the other.

The leſſer of the two circles is for the *Æquinoctiall*, having in the midſt of the inner ſide or thickneſſe, a line round it, which is the true *Æquinoctiall* circle, divided into twice twelue houres, from the two oppoſite points in which it is faſtened within the greater.

The greater and outer of the two circles is the *Meridian*. One quarter whereof, beginning at one of the points in which the *Æquinoctiall* is hung, is divided into ninety degrees.

The Diameter is faſtened to the *Meridian* in two oppoſite points or poles, one of them being the very end of the Quadrant, and is the *North Pole*. Wherefore it is perpendicular to the *Æquinoctiall*, having his due poſition. The diameter is broad, and ſlit in the middle: and about the ſlit on both ſides are the moneths and dayes of the yeer. And within this ſlit is a little ſliding plate pierced through with a ſmall hole: which hole in the motion of it, while it is applied to the dayes of the yeer, repreſenteth the *Axis* of the world.

The

The little Ring whereby the Inſtrument hangeth, is made to ſlip up and down along the Quadrant: that ſo by help of a little tooth annexed, the Inſtrument may be rectified to any elevation of the *Pole*.

II. *The uſe of it.*

IN uſing this Inſtrument, Firſt, the tooth of the little Ring muſt carefully be ſet to the height of the *Pole* in the Quadrant, for the place wherein you are.

Secondly, the hole of the ſliding plate within the ſlit, muſt be brought exactly unto the day of the moneth.

Thirdly, the *Æquinoctiall* is to be drawn out, and by means of the two ſtuds in the *Meridian* ſtaying it, it is to be ſet perpendicular thereto.

Fourthly, Gueſſe as neer as you can at the houre, and turn the hole of the little plate toward it.

Laſtly, Hold the Inſtrument up by the little Ring, that it may hang freely with the *North Pole* thereof toward the North: and move it gently this way and that way, till the beams of the Sun-ſhining thorow that hole, fall upon that middle line within the *Æquinoctiall*: for there ſhall be the houre of the day: And the *Meridian* of the Inſtrument ſhall hang directly *North* and *South*.

Theſe Inſtrument all Dials are made in braſſe by Elias Allen *dwelling over againſt* St. Clements *Church without Temple Barre, at the ſigne of the* Horſe-ſhoe *neare* Eſſex *Gate.*

FINIS.